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Forest Service

**Intermountain
Forest and Range
Experiment Station**

General Technical
Report INT-101

April 1981

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Effectiveness of Douglas-Fir Beetle Antiaggregative Pheromone Applied by Helicopter

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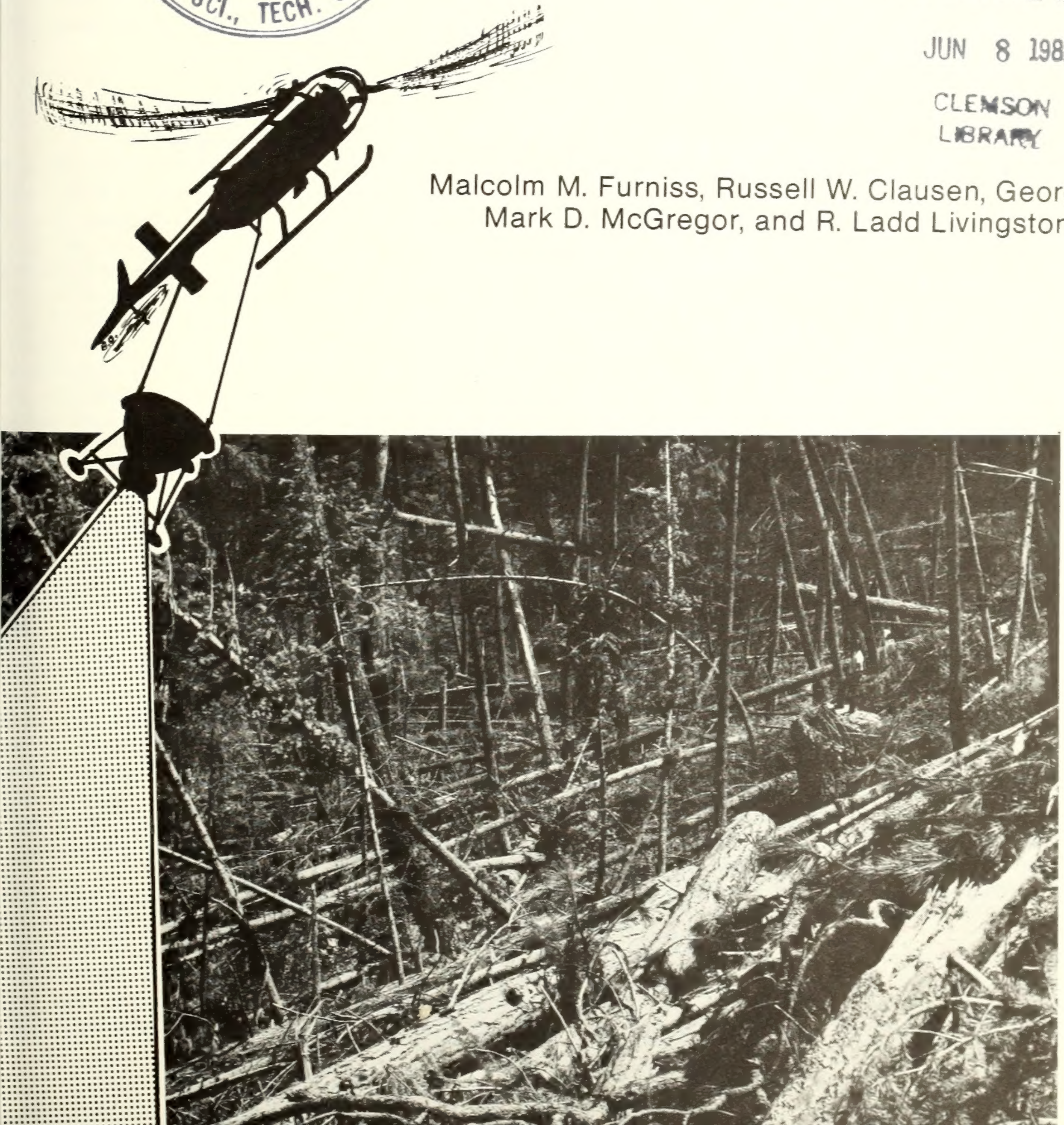
Malcolm M. Furniss, Russell W. Clausen, George P. Markin
Mark D. McGregor, and R. Ladd Livingston



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RESEARCH SUMMARY

A granular controlled release formulation containi
approximately 1.7 percent Douglas-fir beetle ar
aggregative pheromone, 3-methyl-2-cyclohexen-l-or
was applied prior to beetle flight by helicopter
replicated 2 hectare plots each containing 10 fell
Douglas-firs. Rates of application ranged from 1.41
9.80 kg/ha as measured on plots by 0.28 square me
conical traps. Bark samples taken in August disclos
that the pheromone treatments had reduced Dougl
fir beetle attacks by 92 to 97 percent and progeny by
to 99 percent. Results were consistent with earlier te
involving hand broadcasting the controlled-relea
formulation on smaller plots. Information is also p
sented concerning relationship of Douglas-fir bee
infestation to tree and site variables and densities
other insects on bark samples including entomoph
ous species. The controlled-release formulation is n
ready for pilot testing to prevent expansion of Dougl
fir beetle populations in Douglas-fir windthrow a
subsequent killing of susceptible trees in surroundi
stands.

ACKNOWLEDGMENTS

Many persons contributed to the earlier developmental work that led to this test as noted in the cited publications. The antiaggregative pheromone, 3-methyl-2-cyclohexen-l-one (MCH), was formulated for the test by Zoecon Corporation through arrangement with Dr. J. W. Young of that company. F. W. Honing, USDA Forest Service, Washington, D.C., assisted in obtaining an experimental use permit for the test. MCH content of the formulation was checked independently by Dr. M. Look, USDA Forest Service, Berkeley, Calif. Application technology was developed with the aid of R. Mosmeir, Simplex Corporation, Portland, Oreg.; A. E. Jasumbach, D. R. Hamel, D. R. Bridgewater, USDA Forest Service; and P. E. Joseph, Oregon Department of Forestry. V. J. Hager, USDA Forest Service, corrected mechanical difficulties with the applicator and designed improvements. C. R. Hepner, USDA Forest Service, and N. S. Mehaffie, University of Idaho, supervised the field work and assisted with analyses. Others assisting with fieldwork were K. Gibson, USDA Forest Service, and D. E. Beckman, Idaho Department of Lands. J. Kover, Burlington Northern, Inc., obtained permission for us to locate plots on that company's land. The manuscript was reviewed by Dr. R. A. Werner, Fairbanks, Alaska, Drs. R. D. Averill and E. Holsten, Anchorage, Alaska, M. M. Ollieu, Ogden, Utah, all USDA Forest Service; Dr. W. F. Barr, University of Idaho, Moscow, Idaho; and L. N. Kline, Oregon Department of Forestry, Salem, Oreg.

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Effectiveness of Douglas-Fir Beetle Antiaggregative Pheromone Applied by Helicopter

INTRODUCTION

The Douglas-fir beetle (DFB) (*Dendroctonus pseudo-ugae* Hopkins) ranks among the most economically ıportant bark beetles. Like other bark beetles, its level abundance and destructiveness is mainly an ex-ession of the prevailing condition of its host trees and and environment (Furniss, McGregor, and others 979; Furniss and others, 1981). Beetle populations crease when damaged trees (for example, wind-rown trees) are available. Because they lack resist-ıce, windthrown trees produce many more beetle ogeny than there are attacking beetles. The number standing trees killed by those progeny after emer-ence is a function of abundance of beetles and avail-ility of dense, mature Douglas-fir stands. Such stands e made more susceptible by drought, and possibly by fection with root rots or defoliation by Douglas-fir ssock moths (Berryman and Wright 1978).

Removal of damaged trees and regulation of stand ensity are powerful points of leverage for interrupting e genesis of Douglas-fir beetle outbreaks. Where ossible, windthrown trees should be logged and stand asal area kept below 80 percent of normal stocking. In accessible stands, however, an alternative means of lieving the potential for increase of the beetle popula-on is needed. To meet this need, the beetles' anti-ggregative pheromone, 3-methyl-2-cyclohexen-l-one ICH), is being developed for application to prevent festation of susceptible felled trees.

MCH was chosen for development in preference to apping out DFB with an aggregative pheromone such frontalin because of serious disadvantages of the tter (Furniss 1972): a predacious clerid beetle, *anasimus undatulus* Say, is attracted and destroyed disproportionate numbers to its prey; attracted DFB's "spill over" into trees surrounding the pheromone source causing additional mortality, and if attractant pheromones are used in a "confusion" strategy, vast numbers of trees might be sublethally attacked by DFB, but fatally inoculated with fungi carried by the beetles (Harrington and others 1981).

MCH represses the attraction created when female beetles invade their host tree (Furniss and others 1972; Rudinsky and others 1972). The natural function of MCH is to terminate attack in trees that have been colonized by a sufficient number of female beetles and their mates (Rudinsky and Ryker 1976). MCH has the same effect on the spruce beetle, *Dedroctonus rufipennis* [Kirby]) (Kline and others 1974; Furniss and others 1976). MCH treatment may be ineffective, however, unless applied in the spring prior to initiation of beetle flight and where beetles are below outbreak population density (Furniss, Baker, and others 1979).

The optimum treatment for preventing DFB infestation in susceptible felled trees is approximately 0.25-2.5 g of MCH evaporated per hectare per day (Furniss and others 1974). A granular controlled-release formulation (CRF) containing 2 percent MCH has been developed (U.S. Patent No. 4,170,631) that significantly reduced Douglas-fir beetle attacks in susceptible felled trees when broadcast at 4.6 kg/ha by hand (Furniss and others 1977). We now report the effectiveness of the CRF applied by helicopter to larger plots containing felled Douglas-fir to simulate windthrow.

The DFB population was at a low level during the test. Prevention of "epidemics" by holding the status quo of such low populations in the presence of windstorm damage is the primary objective in using MCH.

METHODS

The study was located between 1 018 and 1 323 m elevation in the upper Palouse River drainage, Latah County, Idaho, in a mixed conifer forest typical of large, productive areas of northern Idaho in which Douglas-fir occurs abundantly as a seral species. Thirty 2-ha plots (122 m x 168 m) were located at 0.4 km or greater intervals along logging roads. The plots were divided into clusters of three, within which each plot was assigned a treatment in the following order: 17.93 kg CRF/ha, control, and 4.48 kg CRF/ha.

During March 13 to 21, 1979, 10 live Douglas-firs were felled on each plot. They averaged 46 cm d.b.h. (R = 33 to 110.5 cm) and 94 years old (R = 70 to 200+). The CRF was applied to plots on April 23 and 24 with a Simplex model 3700 (1.13 m^3) aerial spreader suspended 15 m above the forest canopy from a Bell Jet helicopter (fig. 1 A,B) flying about 72 km/hr. The spreader was modified to restrict output to that required for the test, and the swath width had been determined by airport tests as will be discussed. Application rate was checked with fifteen 0.28 m^2 conical traps per plot (fig. 2 A,B) spaced 24 m apart on three lines 61 m apart and right angle to the direction of flight.

Effectiveness of treatments was checked initially by counting frass piles on May 30 and 31 when most DFB attacks had occurred. All visible frass piles were counted on the stems of each felled tree. Bark samples were removed in August to determine final densities of attacks and progeny. Attacks were counted and galleries were measured on one-half x 2 m samples at 6 m height on the stem and on 30 × 30 cm samples at one-fourth intervals between stump and a 20.3 cm top diameter. Progeny were counted on 15 × 15 cm subsamples.

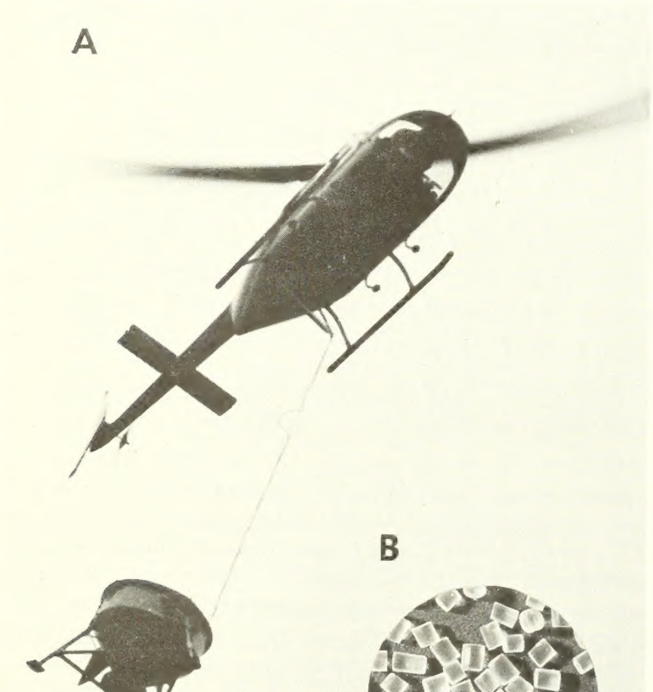


Figure 1.—(A) Aerial spreader and helicopter used to apply controlled-release formulation of MCH; (B) MCH granules.

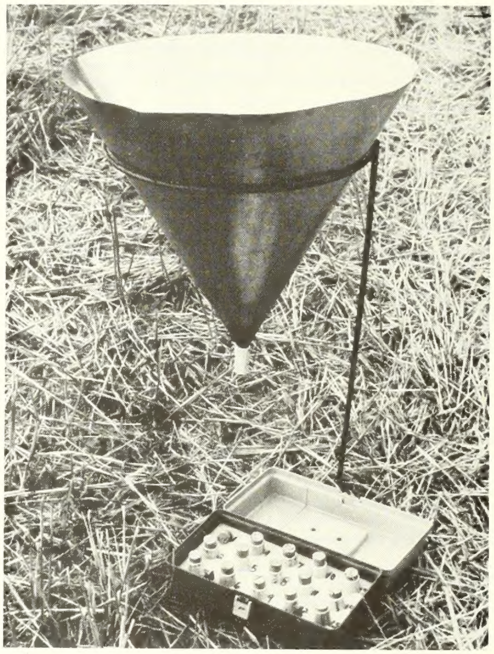
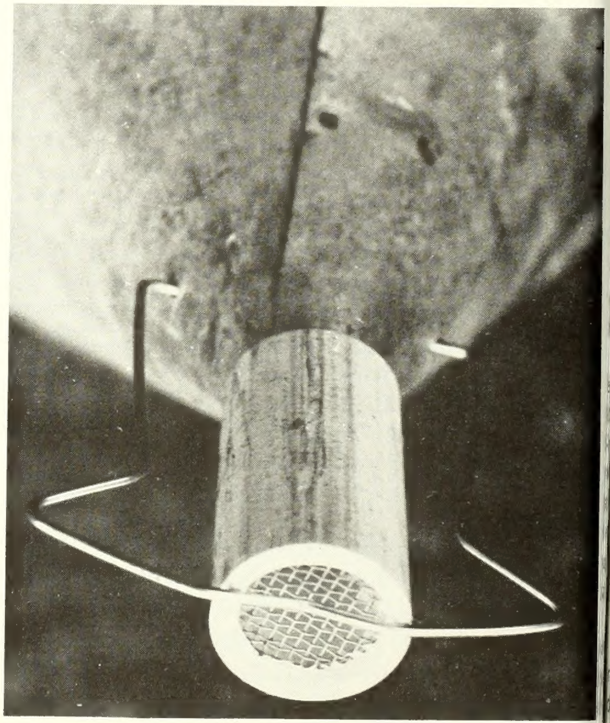


Figure 2.—(A) Conical trap used to determine rate application of controlled-release granules on plot (B) Detail of receptacle and wire support attached bottom of trap to catch granules.



Analyses

Treatment effect was tested for each set of DFB pulation samples and infestation indices by analysis variance. Relationship between weight of CRF anules caught on plots and density of DFB infestation s examined by plotting each observation with a Zeta crement pen plotter. Weights of granules were also otted against density of stands surrounding cone ps in terms of basal area and an ocular estimate of erhead crown density.

Variables, other than treatment, significantly corre- ed with low and high DFB infestation intensity were ught by applying the SCREEN computer program amilton and Wendt 1975). Variables analyzed were: ht intensity in foot candles at the sample location pressed as a percent of full sunlight at that hour of y, d.b.h., age, last 10-year growth, and phloem thick- ss. DFB infestation intensity per plot was tested by pwise regression analysis against elevation, aspect, pographic position, and average basal area.

The newly formulated CRF was analyzed and found to ntain 1.7 percent MCH, slightly less than the desired percent. At the time of application a second sample CRF was extracted and checked for MCH content by formulator and an independent laboratory. The H content was in the range of 1.2 ± 0.2 percent, bstantially less than the freshly formulated material a nth earlier.

RESULTS AND DISCUSSION

Application of CRF

irport tests determined that the overall swath width s about 37 m. A 15-m working swath width was osen after examination of the horizontal distribution granules in order to provide overlap sufficient to ieve an even distribution of the desired rate. During application of granules, difficulties were en- ntered with the aerial applicator that resulted in a ge of output of granules rather than replications of two programed rates. Since then, these difficulties e been resolved by changes in design, information out which will be published separately.

he average density of granules caught by traps on ts was 1.96 kg/ha, R = 1.41 to 2.61 for the low rate 6.80 kg/ha, R = 4.19 to 9.80 for the high rate. Rates er than intended were due mainly to the mechanical blems mentioned but interception of granules by s may have been involved even though collection of nules was delayed one day to provide time for them ecome dislodged.

eight of granules caught per cone was not strongly ted to stand density in terms of basal area or crown sity at the cone. Diminished catch of granules was evident, however, at basal areas greater than 51.65 m^2/ha and the highest crown density class.

Reduction of DFB Infestation

Trees were examined May 10 but no DFB attack was found. A second examination on May 22 disclosed that attacks had begun during the interim. On May 30 and 31, frass piles on the upper 60 percent of circumference of all trees were counted to compare relative rates of attack:

Treatment	Number of attacks	trees infested
Control	2,453	92
MCH, lower rate	110	41
MCH, higher rate	64	29

The two MCH treatments reduced attacks by 95 and 97 percent compared to the controls. Plots treated at higher rate of application had 42 percent fewer attacks and 29 percent fewer infested trees compared to the lower rate.

Some attacks were yet to occur, however, so we postponed final evaluation until August 1 through 20 when all eggs would have hatched and progeny could be counted. The proportions of life stages on August samples were 74 percent larvae, 18 percent pupae, and 8 percent new adults.

Results of the August sampling are contained in table 1. MCH treatment reduced attack density between 93 and 99 percent and progeny by a similar amount (92 to 99 percent). Both MCH treatments differed significantly ($p > 0.01$) from controls. The higher rate of treatment reduced infestation more than the lower rate, except for numbers of progeny, but the differences were not significant.

DFB attacks were approximately twice as dense on the skyward side than on the underside of tree stems. Probably, temperature on the skyward side of stems was favorable for beetles to bore during initial attack; later, when that side became heated, too few beetles remained in flight to exploit the underside as they normally do (Furniss 1962). In support of this possibility, we found that light intensity of sample locations was positively correlated with attack density. This is not the normal relationship as can be inferred from the work of Rudinsky and Vitė (1956). In most years, samples would include more DFB attacks and progeny on the underside and should be taken there unless examination discloses otherwise.

Attack density varied considerably between the four sampling positions on the stems of plot trees (fig. 3). The highest sampling position (20.3 cm diameter) was least productive of DFB attacks and the test could have been evaluated more efficiently without it.

Table 1.—Densities of Douglas-fir beetle infestation on samples from upper and lower sides of plot trees[1]

Treatment	Upper side		Lower side	
	Attacks	Gallery length	Attacks	Progeny
	Number/m^2	cm/m^2	Number/m^2	Number/m^2
Control	6.9	170.2	[2]2.7	68.9
MCH, lower	0.5	7.6	0.1	2.1
MCH, higher	0.06	1.0	0.05	5.4

[1] Upper side samples were 0.5 x 2.0 m on which attacks and gallery length were determined; lower side samples were 30 x 30 cm for attacks and 15 x 15 cm for progeny.

[2] Average = 3.5 if the unproductive top (20 cm diameter) sample position is omitted; meanwhile, average for MCH not affected.

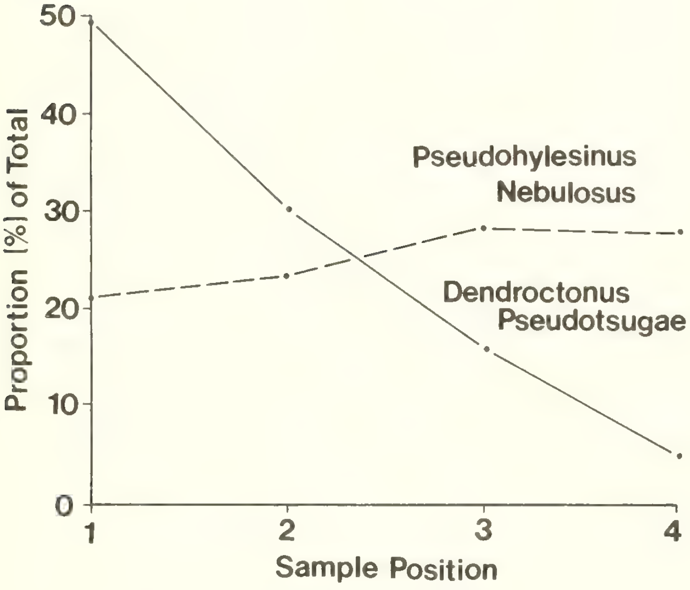


Figure 3.—Distributions of Douglas-fir beetle and Pseudohylesinus nebulosus *by location of sample.*

Relationships of Nontreatment Variables with DFB Infestation

We noted a wide range of DFB attack density within and between plots of the same treatment category (especially controls). Because treatment could not explain those differences, we sought to correlate other variables with density of infestation.

Thirty pairs of trees having lowest (mostly zero) and highest DFB attack density were tested by the SCREEN program to determine if the following variables were correlated significantly ($p = 0.05$) with presence or absence of DFB: relative light intensity at the sampl age, d.b.h., last 10 years' growth, and phloem thicknes None was significantly correlated in this particul instance. We know from personal observation, ho ever, that those variables are normally positively c related with successful DFB attacks.

We also looked for possible relationships betwee plot characteristics and DFB attack density, by applyi stepwise multiple regression analysis. Factors r gressed on DFB attack density were: elevation, aspe basal area, topographic position, and slope. None those factors was related significantly to intensity DFB infestation.

We conclude that the extremely low DFB populati resulted in the wide range of attack density. We thi that beetles tended to aggregate on the first attack trees and that other plot trees were not attack subsequently because there were virtually no m beetles available. The objective of the test was attai ed, however, because we determined that MCH effe on this endemic population was proportional to that o many times greater population in previous years (F niss and others 1974, 1977).

Other Insects

The scolytid, *Pseudohylesinus nebulosus* (Lec.), w the most abundant insect in plot trees. Its attac preceded those of the DFB. Rate of occurrence of *nebulosus* on samples increased with sampling hei (fig. 3). MCH had no effect on frequency of occurrence *P. nebulosus* in plot trees.

Larvae of the weevil, *Pissodes fasciatus* Lec, w present more often ($p = 0.01$) on MCH plot tre Frequencies of infested samples by treatment we MCH, higher rate (131), MCH, lower rate (108), a control (61).

Table 2.—Average densities per square meter of insect predators and a parasite by treatment

Treatment	*Coeloides vancouverensis*	*Medetera* sp.	Cleridae	*Temnochila chlorodia*
Control	27.8	2.9	2.0	0.1
MCH, lower	7.4	0	.1	0
MCH, higher	.1	0	.1	0

Another scolytid, *Scolytus monticolae* Sw., began nfesting trees in early July, but was relatively rare, being resent on only 16 of 1,200 bark samples (1.3 percent). was twice as frequent in the upper one-half of the unk as in the basal one-half, but was unaffected by ICH treatment.

Five species of entomophagous insects were tallied n samples (table 2). MCH has no known effect on nem. Their order of abundance was the same as bserved in previous years (Furniss and others 1979). he braconid wasp, *Coeloides vancouverensis* (Dalla orre) (=*brunneri Vier.*), was most abundant, followed by dolichopodid fly, *Medetera* sp., clerid beetles, includig *Thanasimus undatulus* Say and *Enoclerus sphegeus* ab., and the ostomid, *Temnochila chlorodia* Mann. hese species appear to be more important controlling ctors at low DFB population densities inasmuch as neir densities in trees did not change markedly during ne course of an outbreak not far from this test area urniss and others 1979). Thus, working in concert with ICH treatment, entomophagous insects might exert dditional controlling influence.

CONCLUSIONS AND RECOMMENDATIONS

Results of the test confirm earlier findings and idicate that aerial application of 4.48 kg CRF/ha will rduce by over 90 percent infestation of windthrown ouglas-fir by Douglas-fir beetles. Effectiveness of CH treatment was evaluated with similar accuracy ing any of the three sets of sample data described rlier. Attack density, however, was more easily dermined by counting frass piles than by removing bark mples, and the data were available sooner. Frass ust be counted when attacks are nearly complete, but fore frass is blown or washed away. Approximately ne 1 is a suitable time in areas represented by this idy.

Because MCH has no demonstrable direct effect on entomophagous insects that help to maintain low DFB population densities (Furniss and others 1979), it is preferable to aggregative pheromones (frontalin or seudenol). Frontalin and seudenol attract the predator, *Thanasimus undatulus* in disproportionate numbers and would result in its destruction in a trap-out effort. An even more worrisome aspect of the use of aggregative pheromones—especially in a "confusion" strategy —where those pheromones would be applied areawide to the forest, is the possibility of trees being attacked at a sublethal density that would result in inoculating vast numbers of trees with fungi. *Fomitopsis pinicola* (Sw. ex Fr.), *Cryptoporus volvatus* (P.), and other fungi are known to be carried by the beetles (Harrington and others 1981).

Application of the CRF to emit MCH throughout the spring beetle flight would provide an alternative to leaving inaccessible windthrow untreated. When sufficient merchantable size Douglas-firs are felled by windstorms, the CRF will be pilot tested on large (40 to 120 ha) replicated plots at a rate of 4.48 kg/ha for comparison with similar but untreated areas. Registration requirements are being determined in consultation with the Environmental Protection Agency.

Other recommended future research includes testing the CRF against spruce beetle, which breeds to epidemic numbers in felled spruces in many areas of western North America, and applying the controlled-release technology to develop pine engraver inhibitory pheromone (Birch and others 1977; Furniss and Livingston 1979) for prevention of outbreaks in pine slash.

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A controlled-release formulation containing 1.7 percent antiaggregative pheromone, 3-methyl-2-cyclohexen-l-one, was applied by helicopter at rates between 1.41 and 9.80 kilograms of controlled-release formulation per hectare to 2-hectare plots each containing 10 simulated windthrown Douglas-fir. Treatment reduced Douglas-fir beetle infestation in felled trees by 92 to 99 percent compared to untreated plots.

KEYWORDS: Douglas-fir beetle, 3-methyl-2-cyclohexen-l-one, MCH, pheromone, controlled-release formulation, preventive control

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General Technical
Report
INT-102

February 1981

A COMPUTERIZED BIBLIOGRAPHY OF SELECTED SAGEBRUSH SPECIES (GENUS *ARTEMISIA*) IN WESTERN NORTH AMERICA

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THE COMPILERS

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RESEARCH SUMMARY

This unannotated bibliography of sagebrush (primarily in the *Tridentatae* section of *Artemisia*) covers the period from the late 1800's to 1980. It deals with plant ecology and management aspects of grazing, control, revegetation, wildlife, and watershed. The sagebrush species from the section *Tridentatae* covered in the index are *A. arbuscula, A. bigelovii, A. cana, A. longiloba, A. nova, A. pygmaea, A. rigida, A. spinescens, A. tridentata, and A. tripartita.* The subspecies of *A. tridentata*—*A. t. tridentata, A. t. wyomingensis,* and *A. t. vaseyana*—are separated where known. Other species included are *A. frigida, A. campestris, A. filifolia, A. ludoviciana, A. dracunculoides,* and *A. longifolia.*

This bibliography is also available on a computer database and can be searched by selected key or title words through WESTFORNET, an information service operated by the Forest Service.

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A COMPUTERIZED BIBLIOGRAPHY OF SELECTED SAGEBRUSH SPECIES (GENUS *ARTEMISIA*) IN WESTERN NORTH AMERICA

compiled by
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INTRODUCTION

Sagebrush is an important shrub in western North America. Shrubby *Artemisia* species are associated with over 200 million acres in the western United States alone. Management and research decisions often require a review of the literature to obtain information about the expected effect of certain management practices on the ecology and biology of sagebrush.

We have attempted to compile and index the literature on sagebrush from the 1800's to 1980. Biological Abstracts, Herbage Abstracts, Dissertation Abstracts, and the bibliographies of papers were used to compile the citations. Articles directly concerning sagebrush or sagebrush-dominated communities are the core of the bibliography. We have included articles dealing with description, management, and research in communities where *Artemisia* is not dominant but is an important component, and also articles dealing with secondary succession or manipulated vegetation following sagebrush removal. The effects of grazing on *Artemisia* and associated plants, and the effects of sagebrush on domestic and wild animals constitute a great number of he citations.

The primary emphasis of the bibliography is on the ection *Tridentatae* of *Artemisia*. However, some *rtemisia* species are included because they occur with he species in this section or are an important comonent of the vegetation in western North America. Subspecies separation has been included where ecological difference has been demonstrated. The species and subspecies included from the section *Tridentatae* are:

A. arbuscula	(ARAR)	Low sagebrush
A. bigelovii	(ARBI)	Bigelow sagebrush
A. cana	(ARCA)	Silver sagebrush
A. longiloba	(ARLOB)	Alkali sagebrush
A. nova	(ARNO)	Black sagebrush
A. pygmaea	(ARPY)	Pigmy sagebrush
A. rigida	(ARRI)	Stiff sagebrush
A. spinescens	(ARSP)	Bud sagebrush
A. tridentata	(ARTR)	Big sagebrush
A. tridentata tridentata	(ARTRTR)	Basin big sagebrush
A. tridentata vaseyana	(ARTRVA)	Mountain big sagebrush
A. tridentata wyomingensis	(ARTRWY)	Wyoming big sagebrush
A. tripartita	(ARTRP)	Threetip sagebrush

Other species included are:

A. frigida	(ARFR)	Fringed sagebrush
A campestris	(ARCAM)	Common sagewort
A. filifolia	(ARFI)	Sand sagebrush
A. ludoviciana	(ARLU)	Louisiana sagewort
A. dracunculoides	(ARDR)	Falsetarragon sagewort
A. longifolia	(ARLO)	Longleaf sagewort

Because of the proliferation of literature about *Artemisia,* we have used FAMULUS, a computerized personal documentation system designed by T. B. Yerke of the Forest Service to compile the bibliography. Computer searches using the keywords listed in the index and/or title can be requested by Forest Service employees through the WESTFORNET Librarian, Intermountain Forest and Range Experiment Station, Ogden, Utah. If desired, a tape or card deck of the bibliography can be made for others to use.

The index of keywords, compiled to assist in the use of the bibliography, is general and overlapping. Acronyms were used for the plant species and are generally the first two letters of the genus/species/subspecies name. These are given in the listing of plant species for the bibliography. Citations can be found by using species or subject matter alone, or in combination with other keywords. We did not read all the articles we have cited, and there will undoubtedly be errors, because we indexed from title only on many of the citations. Information on deletions or additions to the index or any additional references for the bibliography would be appreciated. The computer bibliography, updated periodically, will give land managers and researchers a working tool to assist them in making decisions about the sagebrush-grass ecosystem.

We appreciate the help of E. F. Schlatterer, A. A. Beetle, and T. Weaver in obtaining citations, and of J. A. Marshall, R. B. Campbell, and R. Hamilton in preparing this bibliography for the computer.

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1981 A computerized bibliography of selected sagebrush species (genus *Artemisia*) in western North America. USDA For. Serv. Gen. Tech. Rep. INT-102, 107 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

This unannotated bibliography of sagebrush, covering the period from the late 1800's to 1980, deals with the plant ecology and management aspects of *Artemisia*, primarily the section *Tridentatae*. Emphasis is on grazing, control, revegetation, wildlife, and watershed literature. The citations are on a computer retrieval system and can be searched by selected key or title words through WESTFORNET.

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GROWING COLORADO PLANTS FROM SEED: A State of the Art

VOLUME I: SHRUBS

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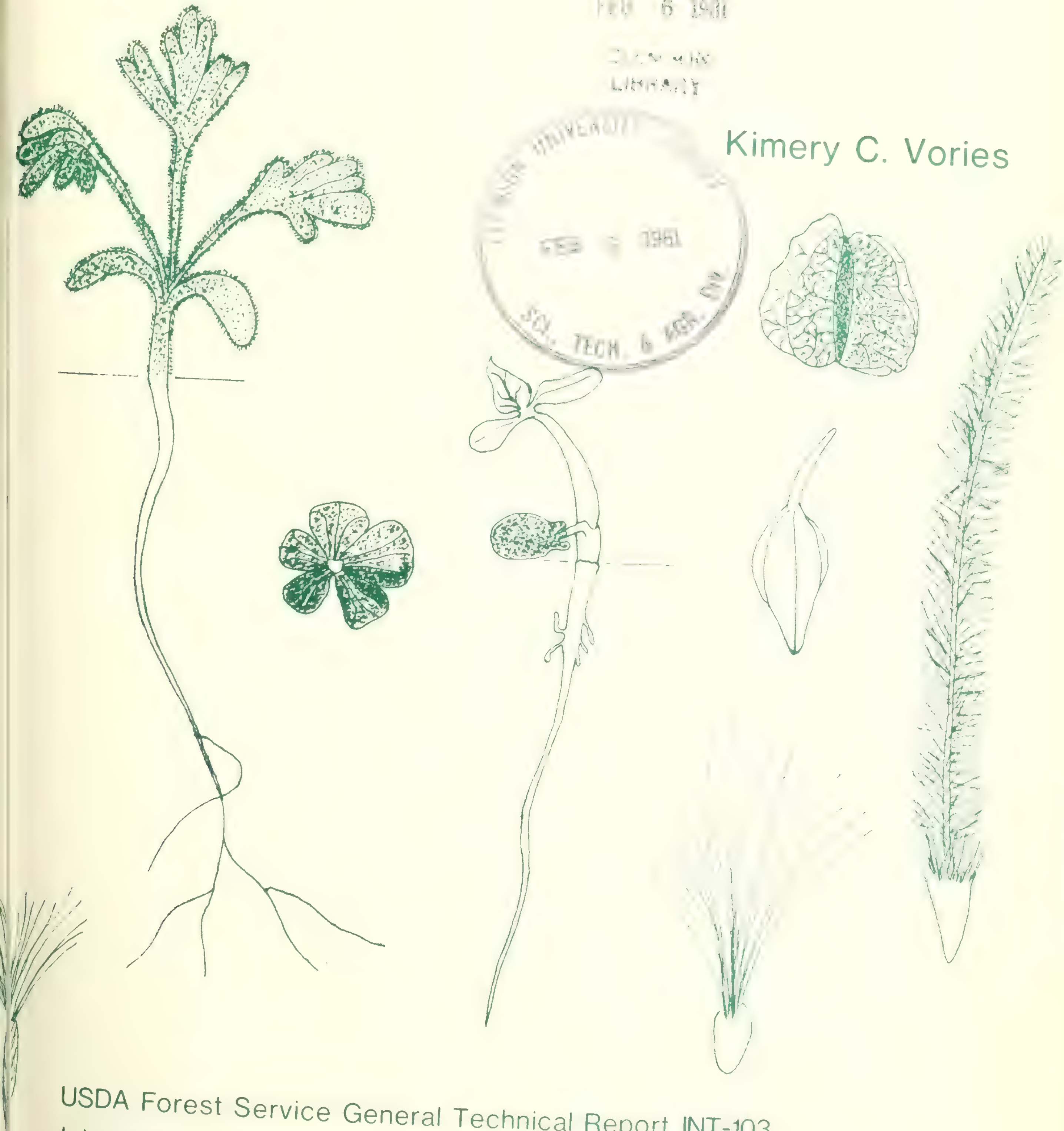
Kimery C. Vories



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GROWING COLORADO PLANTS FROM SEED: A State of the Art

VOLUME I: SHRUBS

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THE AUTHOR

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RESEARCH SUMMARY

Information on the germination and establishment of wildland shrubs has increased with interest in reestablishing self-supporting ecosystems on lands disturbed by human activity. Available information is of variable quality, quantity, and accessibility. The purpose of this investigation was to compile existing germination and plant propagation information for persons planting native or naturalized Colorado shrubs. Included is information on the seed procurement, pretreatment, laboratory germination, and culture of 127 Colorado shrub species. Also included are 234 literature citations, a list of the Colorado shrub species that have been evaluated by USDA Soil Conservation Plant Materials Centers, addresses of plant materials centers in the western United States, a list of the commercial suppliers of Colorado shrub seed, seedlings, and transplants, and a list of the addresses of commercial suppliers of Colorado shrubs.

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INTRODUCTION

Many western reclamation sites are characterized by the absence of vegetative cover, imited moisture, inadequate organic matter, harsh climate, and infertile soils. The expense f improving these conditions by topsoiling, grading, cultivation, irrigation, fertilization, nd intensive management is prohibitively expensive in terms of the land's potential agricul- ural value. One alternative is to establish vigorous self-sustaining ecosystems similar to ative ecosystems. This alternative, however, requires the reclamation specialist to establish wide variety of native and domesticated plants in a wide variety of western environments.

With the recent development of such computerized information storage and retrieval systems s the Plant Information Network (Vories and Sims 1977), we have a sophisticated tool for deter- ining plant adaptability and the desirability of planting on a given site. It soon becomes pparent, however, that even with the knowledge that a plant would be desirable or adaptable n a given site, our knowledge of how to propagate and cultivate nondomesticated plants under ield conditions generally is inadequate. Information is scattered through the literature and ifficult to collect and compile. The Forest Service publication "Seeds of Woody Plants in he United States" (Schopmeyer 1974) has greatly enhanced the accessibility of information ertaining to shrubs and trees. Many Colorado species were not covered because of that blication's national coverage.

The objectives here are to:

1. Make all published information on the germination and culture of Colorado shrubs ailable in an easily used and understood publication.

2. Identify the Colorado shrubs that have been researched extensively and those that are latively unknown in terms of germination characteristics and planting technology.

3. Identify publications that would be useful for persons interested in landscaping or feld establishment of Colorado shrubs.

METHODS

The investigation consisted of three phases. Phase 1 was the actual literature search, an exhaustive search of bibliographies, publications, periodicals, and government agency reports. The information was recorded on special forms and each article abstracted or summa- ried. Phase 2 was an evaluation of reports on the results of tests with Colorado shrubs by USA Soil Conservation Service Plant Materials Centers. A card file was set up indexing the species being evaluated. Phase 3 was an evaluation of information provided by commercial suppliers concerning the types and names of plant materials they handled. This phase consisted of recording whether a species was supplied as seed, bare root seedlings, or potted trans- plants, and which suppliers handled it.

The information is presented by species in four general categories: procurement, pretreat- ent, laboratory germination, and cultural practices. Because of wide variability in the uality of information available, the source of each bit of information is cited. The order f citation is from the newest to the oldest, the supposition being that, in the majority of ases, the most recent citations should be those of the highest quality. Some earlier publica- ics, however, can only be described as classics.

SUMMARY OF RESULTS

According to information provided by the Plant Information Network, Department of Botany nd Plant Pathology, Colorado State University, there are between 204 and 248 native or turalized Colorado shrub species. (The difference of 44 species being those plants which ey have characteristics of both shrubs and trees.) The author located information in 234 fferent publications on the 127 species listed in this publication.

Nine of the shrubs had excellent seed propagation information, with substantial amounts of information in each of the four main information categories. They were: *Amelanchier alnifolia, Arctostaphylos uva-ursi, Artemisia tridentata tridentata, Atriplex canescens, A. confertifolia, A. gardneri* (formally called *A. nuttallii*), *Ceratoides lanata, Cercocarpus montanus,* and *Purshia tridentata*. Twenty-three shrubs had an adequate amount of seed propagation information in all four categories, although the information was not as extensive as for the nine above. They were: *Acer glabrum, Amelanchier utahensis, Artemisia arbuscula, A. cana, A. nova, Ceanothus velutinus, Cercocarpus ledifolius, Cornus stolonifera, Cowania mexicana stansburiana, Elaeagnus angustifolia, Grayia spinosa, Mahonia repens, Prunus americana, P. virginiana, Rhus glabra, R. trilobata, Rosa nutkana, Salix bebbiana, S. exigua, S. scouleriana, Sambucus coerulea, Shepherdia argentea,* and *Tamarix pentandra*. Twenty shrubs had marginal seed propagation and laboratory germination information in addition to having incomplete cutural information. They were: *Amorpha canescens, A. fruticosa, A. nana, Arctostaphylos patula, Atriplex obovata, Chrysothamnus nauseosus, C. viscidiflorus, Clematis ligusticifolia, Ephedra viridis, Fallugia paradoxa, Juniperus communis, Peraphyllum ramosissimum, Ribes cereum, Rubus occidentalis, Sambucus canadensis, S. racemosa, Shepherdia canadensis, Symphoricarpos albus albus, S. orbiculatus,* and *Yucca glauca*. There are major gaps in the seed propagation information for the remaining 75 species listed.

A poll of USDA Soil Conservation Service Plant Materials Centers revealed that 107 native or naturalized Colorado shrubs were presently being evaluated. Although these centers rarely have seed available for other uses, they should be a good source of information on the propagation of plants that have not been evaluated in the literature.

Seventy-one native or naturalized Colorado shrub species were found to be at least potentially available from 28 different commercial suppliers. The annual seed crop, time of year, and numerous other variables determine whether or not these species will be available. Under favorable conditions, these species can be obtained as seed, bare root seedlings, or containerized stock.

Additional sources of propagation information related to Colorado shrub species can be obtained through the Intermountain Station's Shrub Sciences Laboratory in Provo, Utah, or through the Rocky Mountain Forest and Range Experiment Station.

GERMINATION AND PROPAGATION INFORMATION BY SPECIES

ACER GLABRUM Torr. (Rocky Mountain Maple)

FAMILY: Aceraceae
LIFEFORM: Native tree 2-6 m tall (Harrington, 1964)
FRUIT: Samara 2-3 cm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 7,820-20,300--avg 13,430 (Olson & Gabriel, 1974); 13,200-20,300 (Swingle, 1939)
SEED MATURITY: Aug-Sep, 1-3 years between seed crop (Olson & Gabriel, 1974); Summer (Swingle, 1939)
METHOD OF COLLECTION: Hand pick or shake trees onto canvas (Olson & Gabriel, 1974)

PRETREATMENT

METHOD OF STORAGE: Dry in sealed containers at 35-41°F (Olson & Gabriel, 1974); Cellar (Swingle, 1939)
DURATION OF GOOD VIABILITY: 1-2 years (Olson & Gabriel, 1974)
STRATIFICATION AND SCARIFICATION: Warm stratify at 68-86°F for 180 days then moist chill at 37-41°F for 180 days (Olson & Gabriel, 1974); Moist chill at 3-5°C for 2-6 months (Heit, 1968); Moist chill at 41°C for 90 days (Babb, 1959); Needs a long stratification period (Peterson, 1953); Moist chill December thru March (Swingle, 1939)

LABORATORY GERMINATION

TEMPERATURE: Best at a constant 50-60°F (Olson & Gabriel, 1974)
MOISTURE: Moist (Olson & Gabriel, 1974)
GERMINATION ENERGY: 40% in 30 days (Olson & Gabriel, 1974)
GERMINATION CAPACITY: 52% (Swingle, 1939)
COMMENTS: Difficult to overcome dormancy (Heit, 1968)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-1" deep (Olson & Gabriel, 1974)
PLANTING TIME: Best in fall but okay in spring with stratified seed (Olson & Gabriel, 1974; Babb, 1959); Fall or spring (Swingle, 1939)
EXPOSURE: Shade during establishment (Olson & Gabriel, 1974)

AMELANCHIER ALNIFOLIA (Nutt.) Nutt. (Saskatoon Serviceberry)

FAMILY: Rosaceae
LIFEFORM: Native shrub 1-4 m tall (Harrington, 1964)
FRUIT: Berry-like pome 5-9 mm in diameter (Blauer et al., 1975)
SEED: Small with leathery seed coat (Brinkman, 1974a)

PROCUREMENT

SEEDS/LB: 36,000-113,800--avg 82,000 (Brinkman, 1974a); 45,395 (Plummer et al., 1968); 51,300-112,650 (Swingle, 1939); 36,300 (McKeever, 1938)
SEED MATURITY: Seed crop every 3-5 years UT (Blauer et al., 1975); Jul-Aug (Brinkman, 1974a); Jul 10-Sep 15 UT (Plummer et al., 1968); Early summer (Swingle, 1939)
METHOD OF COLLECTION: Knock onto a canvas or into hoppers (Plummer et al., 1968)
METHOD OF CLEANING: Dybvig with water, dry and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Dry storage in sealed containers at 41°F (Brinkman, 1974a; Swingle, 1939)
DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968); Less than 5 years (King, 1947)
STRATIFICATION AND SCARIFICATION: Moist chill at 33-43°F for 4-6 months (Brinkman, 1974a; Heit, 1968); Moist chill at 1°C for 120 days, acid treatment not necessary (McLean, 1967); 60 minute soak in sulfuric acid aided germination (Waitman, 1961); Moist chill at 41°F for 120 days (Babb, 1959); Moist chill at 5°C for 98-112 days, 30, 60, and 90 minute soaks in sulfuric acid did not aid germination (Hervey, 1955); Moist chill at 40°F for 140 days (Swingle, 1939); Moist chill at 5°C in sand for 140 days (McKeever, 1938)

LABORATORY GERMINATION

TEMPERATURE: Either 70°F constant or alternating 86°F day and 68°F night (Brinkman, 1974a); Germinates well as low as 1.5°C (Hargrove, 1937)
MOISTURE: Moist (White, 1968)
LIGHT: Light not necessary (Brinkman, 1974a)
GERMINATIVE ENERGY: 76% in 150 days (Monsen & Christensen, 1975); 50% in 8 days (Brinkman, 1974a)
GERMINATIVE CAPACITY: 85% in 180 days (Monsen & Christensen, 1975); 62-70% in 30-70 days (Brinkman, 1974a); 98% (McLean, 1967); 3% (Hervey & Boyd, 1953); 99% in 6 days (McKeever, 1938)
COMMENTS: Large percentage of infertile and insect infested seeds (White, 1968); Should remove fruit from seed before germination (Hervey & Boyd, 1953); Dormancy is due to dormant or immature embryo (McKeever, 1938)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Brinkman, 1974a)
PLANTING TIME: Fall or with stratified seed in spring (Monsen & Christensen, 1975; Brinkman, 1974a); Spring (Swingle, 1939)
EXPOSURE: 1/2 shade during first year (Brinkman, 1974a); Shade during establishment (White, 1968; Hervey, 1955)

SOIL TEXTURE: Sandy (Brinkman, 1974a); Medium (Sutton & Johnson, 1974); Not on clayey soils (White, 1968)
SOIL pH: 6.0-7.0 (Sutton & Johnson, 1974); 5.3-7.8 (White, 1968)
SOIL DEPTH: Deep (Sutton & Johnson, 1974)
ORGANIC MATTER: If possible (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Plant soon after collection, drill at 25 seed/linear foot, mulch (Brinkman, 1974a)
GREENHOUSE PLANTING: Can be propagated vegetatively with soft wood and root cuttings (Harris, 1961)
FIELD PLANTING: Under normal conditions germination begins in spring under snow or shortly after snowmelt (McKeever, 1938)

AMELANCHIER UTAHENSIS Koehne (Utah Serviceberry)

FAMILY: Rosaceae
LIFEFORM: Native shrub 1-4 m tall (Harrington, 1964)
FRUIT: Berry-like pome 6-10 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 25,800 (Plummer et al., 1968); 31,500 (Swingle, 1939)
SEED MATURITY: Aug 25-Apr 1 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Knock onto canvas or into hopper (Plummer et al., 1968)
METHOD OF CLEANING: Dybvig with water, dry, fan (Plummer et al., 1968)

PRETREATMENT

DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 3-5°C for 1.5 months (Heit, 1970) or 2-6 months (Heit, 1968)

LABORATORY GERMINATION

TEMPERATURE: 6°C constant (Monsen & Christensen, 1975); 30°C day and 10°C night alternating (Heit, 1970)
MOISTURE: Moist (White, 1968)
GERMINATION ENERGY: 40% in 60 days (Monsen & Christensen, 1975)
GERMINATIVE CAPACITY: 95% in 150 days (Monsen & Christensen, 1975); 90% in 15 days (Heit, 1970)
COMMENTS: Large percentage of infertile and insect infested seed (White, 1968)

CULTURAL PRACTICES

PLANTING TIME: Fall (Monsen & Christensen, 1975)
EXPOSURE: Shade during establishment (White, 1968); Sun when mature (Stark, 1966)
SOIL TEXTURE: Not on clayey soils (White, 1968); Medium to coarse (Stark, 1966)
SOIL pH: 5.3-7.8 (White, 1968)
SOIL DEPTH: Moderate to deep (Stark, 1966)
SOIL MOISTURE: Dry, 8-14" precipitation zone (Stark, 1966)
DRAINAGE: Well-drained (Stark, 1966)

AMORPHA CANESCENS Pursh. (Leadplant Amorpha)

FAMILY: Fabaceae
LIFEFORM: Native shrub 30-100 cm tall (Harrington, 1964)
FRUIT: Small, 2-seeded legume (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 296,000 (Brinkman, 1974b); 87,900-105,754 (Swingle, 1939)
SEED MATURITY: Aug-Sep (Brinkman, 1974b); Late summer (Swingle, 1939)
METHOD OF COLLECTION: Strip from branches (Brinkman, 1974b)

PRETREATMENT

METHOD OF STORAGE: Dry in sealed containers at 41°F (Brinkman, 1974b; Swingle, 1939)
STRATIFICATION AND SCARIFICATION: Sow in fall or soak in hot water for 10 minutes (Brinkman, 1974b); Soak in hot water at 180-200°F for 12 hours then moist chill at 41°F for 30 days (Babb, 1959)

LABORATORY GERMINATION

TEMPERATURE: 86°F day and 68°F night alternating (Brinkman, 1974b)
GERMINATIVE ENERGY: 79% in 14 days (Brinkman, 1974b)
GERMINATIVE CAPACITY: 28% in 15-40 days (Brinkman, 1974b)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-3/16" (Brinkman, 1974b)
PLANTING TIME: Fall (Brinkman, 1974b; Swingle, 1939)
GREENHOUSE PLANTING: Reproduces well by cuttings (Swingle, 1939)
FIELD PLANTING: Sow in pods (Brinkman, 1974b)

AMORPHA FRUITICOSA L. (Indigobush Amorpha)

FAMILY: Fabaceae
LIFEFORM: Native shrub 2-4 m tall (Harrington, 1964)
FRUIT: A legume 7-8 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 72,000-82,000--avg 77,000 (Brinkman, (1974b); 54,613-67,200 (Swingle, 1939)
SEED MATURITY: Aug (Brinkman, 1974b); Late summer or fall (Swingle, 1939)
METHOD OF COLLECTION: Strip from branches (Brinkman, 1974b)

PRETREATMENT

METHOD OF STORAGE: Dry in sealed containers at 41°F (Brinkman, 1974b; Swingle, 1939)
DURATION OF GOOD VIABILITY: 3-5 years (Brinkman, 1974b)
STRATIFICATION AND SCARIFICATION: Sow in fall or soak in hot water for 10 minutes, or soak in sulfuric acid for 5-8 minutes (Brinkman, 1974b); Soak in sulfuric acid for 5-8 minutes then moist chill at 41°F for 30 days (Babb, 1959); Stratification not necessary (Swingle, 1939)

LABORATORY GERMINATION

TEMPERATURE: 86°F day and 68°F night alternating (Brinkman, 1974b)
GERMINATIVE CAPACITY: 63% in 15-20 days (Brinkman, 1974b); 42-75% (Swingle, 1939)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-3/16" (Brinkman, 1974b)
PLANTING TIME: Fall or spring (Swingle, 1939)
GREENHOUSE PLANTING: Reproduces well by cuttings (Swingle, 1939)
FIELD PLANTING: Sow in pods (Brinkman, 1974b)

AMORPHA NANA Nutt.
(Dwarfindigo Amorpha)

FAMILY: Fabaceae
LIFEFORM: Native shrub 30-90 cm tall (Harrington, 1964)
FRUIT: One-seeded pod 5 mm long (Rogers, 1931)

PROCUREMENT

SEEDS/LB: 59,682 (Swingle, 1939)
SEED MATURITY: July (Brinkman, 1974b)
METHOD OF COLLECTION: Strip from branches (Brinkman, 1974b)

PRETREATMENT

METHOD OF STORAGE: Dry in sealed containers at 41°F (Brinkman, 1974b)
STRATIFICATION AND SCARIFICATION: Sow in fall, or soak in hot water for 10 minutes, or soak in sulfuric acid for 5-10 minutes (Brinkman, 1974b); Soak in sulfuric acid for 7-8 minutes (Rogers, 1931)

LABORATORY GERMINATION

TEMPERATURE: 86°F day and 68°F night alternating (Brinkman, 1974b); 21°C (Rogers, 1931)
GERMINATIVE ENERGY: 40% in 10 days (Rogers, 1931)
GERMINATIVE CAPACITY: 70% in 30-40 days (Brinkman, 1974b); 50% (Swingle, 1939); 70% in 60 days (Rogers, 1931)
COMMENTS: Germination not affected by subfreezing temperatures or by temperatures of moderately dry heat (68-74°C); the outer part of the outer layer of the seed coat is impermeable to water; scarification with sulfuric acid hastens germination but does not increase the total (Rogers, 1931)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-3/16" (Brinkman, 1974b)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)
FIELD PLANTING: Sow in pods (Brinkman, 1974b)

ARCTOSTAPHYLOS PATULA Greene
(Greenleaf Manzanita)

FAMILY: Ericaceae
LIFEFORM: Native evergreen shrub 1-2 m tall (Harrington, 1964)
FRUIT: Berry-like, 8-10 mm wide with 4-10 seedlike nutlets (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 18,000 (Berg, 1974); 1,700 dry fruits (Swingle, 1939)
SEED MATURITY: Jul-Sep (Berg, 1974); May-Sep NV (Stark, 1966); Aug-Oct (Swingle, 1939)
METHOD OF COLLECTION: Collect by hand or pick off ground, best to collect in late fruit-development (Berg, 1974)
METHOD OF CLEANING: Macerate fruit and separate nutlets by floatation or blowing (Berg, 1974)

PRETREATMENT

STRATIFICATION AND SCARIFICATION: Soak in sulfuric acid for 4 hours then moist chill for 120 days (Berg, 1974); Soak in sulfuric acid for 3-6+ hours then moist chill at 40°F for 90 days in moist sand (Stark, 1966); Moist chill at 40°F for 90 days (Swingle, 1939)

LABORATORY GERMINATION

TEMPERATURE: 86°F day and 68°F night alternating (Berg, 1974)
GERMINATIVE CAPACITY: 20% in 60 days (Berg, 1974)
COMMENTS: Caution needed in scarification process to avoid damaging embryo (Berg, 1974)

CULTURAL PRACTICES

PLANTING TIME: Early summer (Berg, 1974); Spring or fall (Stark, 1966)

EXPOSURE: Sun (Sutton & Johnson, 1974; Stark, 1966)
SOIL TEXTURE: Coarse (Sutton & Johnson, 1974)
SOIL pH: 5.0-6.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate, 12-37" (Sutton & Johnson, 1974)
PRECIPITATION: Less than 20" (50 cm) annually (Sutton & Johnson, 1974); 20" (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)
GREENHOUSE PLANTING: 2-3" branchtips can be propagated in a frame with bottom heat (Mirov & Kraebel, 1939)
NURSERY PLANTING: Mulch seedbeds (Berg, 1974); Manzanitas are easier to propagate from cuttings than seeds (Mirov & Kraebel, 1937)

ARCTOSTAPHYLOS UVA-URSI (L.) Spreng.
(Bearberry)

FAMILY: Ericaceae
LIFEFORM: Native evergreen prostrate shrub with branches to 15 cm long (Harrington, 1964)
FRUIT: Berry-like, 6-10 mm wide with 4-10 seedlike nutlets (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 26,800-58,000 (Berg, 1974); 37,900 (Glazebrook, 1941); 26,800 (Swingle, 1939); McKeever, 1938)
SEED MATURITY: Jun-Aug (Berg, 1974); Jun to fall (Swingle, 1939)
METHOD OF COLLECTION: Collected by hand or picked off ground, best to collect in late fruit development (Berg, 1974)
METHOD OF CLEANING: Macerate fruit and separate nutlets by floatation or blowing (Berg, 1974)

PRETREATMENT

METHOD OF STORAGE: Dry at room temperature (Glazebrook, 1941)
STRATIFICATION AND SCARIFICATION: Soak in sulfuric acid 2-5 hours and plant in early summer or warm stratify at 25°C for 60-120 days then moist chill for 60-90 days (Milstein & Milstein, 1976; Berg, 1974); Soak in sulfuric acid for 7 hours then warm stratify at 20°C for 90 days then moist chill at 1°C for 90 days (McLean, 1967); Warm stratify at 77°F for 60 days then moist chill at 41°F for 60 days, or soak entire stones in sulfuric acid for 3-5 hours (Babb, 1959); Soak in sulfuric acid for 6 hours, then warm stratify at room temperature for 60 days, then moist chill at 4°C for 60 days (Glazebrook, 1941); Soak in sulfuric acid for 3-5 hours (Swingle, 1939); Soak in sulfuric acid for 3-5 hours then overwinter outdoors in mulch frame (Giersbach, 1937a)

LABORATORY GERMINATION

TEMPERATURE: Constant at 75-80°F (Milstein & Milstein, 1976); Either constant at 77°F or alternating 86°F day and 68°F night (Berg, 1974)
GERMINATIVE ENERGY: 70% in 13 days (Glazebrook, 1941)
GERMINATIVE CAPACITY: 15-30 days (Milstein & Milstein, 1976); 30-61% in 16 days (Berg, 1974); 34% (McLean, 1967); 93% in 25 days (Glazebrook, 1941); 75% (Swingle, 1939); 65-76% (Giersbach, 1937a)
COMMENTS: 69% sound seed, dormancy due to hard seed coat and embryo which needs after-ripening (Glazebrook, 1941); Germination unsuccessful (King, 1947).

CULTURAL PRACTICES

PLANTING TIME: Early summer for following spring (Milstein & Milstein, 1976); Early summer (Berg, 1974); Immediately after scarification (Swingle, 1939)
EXPOSURE: Shade or sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Coarse to rocky (Sutton & Johnson, 1974)
SOIL pH: 5.0-6.5 (Sutton & Johnson, 1974)
SOIL DEPTH: Shallow (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
ORGANIC MATTER: Well-drained (Sutton & Johnson, 1974)
GREENHOUSE PLANTING: 2-3" branch tips can be propagated in a frame with bottom heat (Mirov & Kraebel, 1937)
NURSERY PLANTING: Seeds will germinate in 20-40 days (Milstein & Milstein, 1976); Mulch seedbeds, Manzanitas are easier to propagate from cuttings than seed (Berg, 1974)

ARTEMISIA ABROTANUM L.
(Oldman Wormwood)

FAMILY: Asteraceae
LIFEFORM: Introduced shrub 3-5 ft tall (Plummer, 1974)
FRUIT: An achene (Harrington, 1964)

PROCUREMENT

SEED MATURITY: Rarely matures seed in the wild (Plummer, 1974)

CULTURAL PRACTICES

PLANTING TIME: Spring after snowmelt (Plummer, 1974; Stark, 1966)
SOIL pH: Fairly alkaline to fairly acid (Plummer, 1974)
PRECIPITATION: 12-40" (Plummer, 1974); 12" (Stark, 1966)
FIELD PLANTING: Reproduction by seed rarely seen, readily established in early spring by sticking cuttings 10-18" long and 1/8-1/2" in diameter in soil to a depth of 6" or dependable moisture (Plummer, 1974); Poor establishment from direct seeding (Stark, 1966)

ARTEMISIA ARBUSCULA Nutt.
(Low Sagebrush)

FAMILY: Asteraceae
LIFEFORM: Native evergreen shrub 10-30 cm tall (Harrington, 1964)
FRUIT: An achene (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 891,000-1,055,000--avg 972,000 (Deitschman, 1974)
SEED MATURITY: Nov (Stark, 1966)
METHOD OF COLLECTION: Shake, beat or hand strip seed into shoulder hoppers, baskets, or sacks (Deitschman, 1974); Rub or strip seed into containers (Plummer et al., 1968)
METHOD OF CLEANING: Hammermill, fan and screen (Deitschman, 1974); Hammermill (Plummer et al., 1968)

PRETREATMENT

DURATION OF GOOD VIABILITY: 2 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 36°F for 10 days (Deitschman, 1974)

LABORATORY GERMINATION

TEMPERATURE: Alternating 86°F day and 68°F night (Deitschman, 1974)
LIGHT: Better germination in light (Deitschman, 1974)
GERMINATIVE ENERGY: 68-70% in 26-31 days (Deitschman, 1974); 24% (Swingle, 1939)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Deitschman, 1974)
PLANTING TIME: Fall or winter (Deitschman, 1974); Spring (Stark, 1966)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Clay pan soils, very stony (Stark, 1966)
SOIL DEPTH: Shallow (Stark, 1966)
PRECIPITATION: 8-14+" (Stark, 1966)
DRAINAGE: Well-drained (Stark, 1966)
NURSERY PLANTING: Mulch with light straw (Deitschman, 1974)

ARTEMISIA CANA Pursh
(Silver Sagebrush)

FAMILY: Asteraceae
LIFEFORM: Native evergreen shrub 30-200 cm tall (Harrington, 1974)
FRUIT: An achene, 1/4" in diameter (Sutton & Johnson, 1974)

PROCUREMENT

SEEDS/LB: 822,000-870,000 (Eddleman, 1977)
SEED MATURITY: Late summer-fall UT (Sutton & Johnson, 1974)
METHOD OF COLLECTION: Hand pick or use head cutter (Eddleman, 1977)
METHOD OF CLEANING: Mechanical flail (60 seconds), clipper (1/13)/6x60, seed blower (Eddleman, 1977)

PRETREATMENT

METHOD OF STORAGE: Store dry at 20°C (Eddleman, 1977)

LABORATORY GERMINATION

TEMPERATURE: Constant at 10-30°C (Eddleman, 1977)
LIGHT: Light is beneficial for germination (Eddleman, 1977)
GERMINATIVE ENERGY: 50% in 2-6 days (Eddle, man, 1977)
GERMINATIVE CAPACITY: 94-97% (Eddleman, 1977)

CULTURAL PRACTICES

PLANTING DEPTH: Surface (Stark, 1966)
PLANTING TIME: Adequate soil moisture for establishment (Eddleman, 1977); Spring (Stark, 1966)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Coarse (Sutton & Johnson, 1974); Moderately fine (Stark, 1966)
SOIL pH: 6.5-8.5 (Sutton & Johnson, 1974); Slight saline-alkaline tolerance (Stark, 1966)
SOIL DEPTH: Deep (Sutton & Johnson, 1974); Over 60" (Stark, 1966)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
PRECIPITATION: 8-14" (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)

ARTEMISIA FILIFOLIA Torr.
(Sand Sagebrush)

FAMILY: Asteraceae
LIFEFORM: Native evergreen shrub 30-150 cm tall (Harrington, 1964)
FRUIT: An achene (Harrington, 1964)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 56% (Swingle, 1939)

ARTEMISIA FRIGIDA Willd.
(Fringed Sagebrush)

FAMILY: Asteraceae
LIFEFORM: Native undershrub 10-40 cm tall (Harrington, 1964)
FRUIT: An achene (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 4,536,000 (Plummer et al., 1968)
SEED MATURITY: Sep 15-Nov 30 UT (Plummer et al., 1968)

METHOD OF COLLECTION: Rub or strip into containers (Plummer et al., 1968)
METHOD OF CLEANING: Hammermill (Plummer et al., 1968)

PRETREATMENT

DURATION OF GOOD VIABILITY: 2 years (Plummer et al., 1968)

CULTURAL PRACTICES

PLANTING TIME: Spring (Stark, 1966)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Fine to coarse (Sutton & Johnson, 1974)
SOIL pH: 7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Shallow to deep (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)

ARTEMISIA NOVA A. Nels.

(Black Sagebrush)

SYNONOMY: *Artemisia arbuscula nova* (A. Nels.) Crong.; *Artemisia tridentata nova* (A. Nels.) H. & G.
FAMILY: Asteraceae
LIFEFORM: Native evergreen shrub 10-30 cm tall (Harrington, 1964)
FRUIT: An achene (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 825,000-965,000--avg 907,000 (Deitschman, 1974); 907,200 (Plummer et al., 1968)
SEED MATURITY: Oct 15-Nov 30 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Shake, beat, or hand strip seeds into shoulder hopper, basket, or sack (Deitschman, 1974); Rub or strip into containers (Plummer et al., 1968)
METHOD OF CLEANING: Hammermill, fan and screen (Deitschman, 1974); Hammermill (Plummer et al., 1968)

PRETREATMENT

DURATION OF GOOD VIABILITY: 2 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 36°F for 10 days (Deitschman, 1974)

LABORATORY GERMINATION

TEMPERATURE: Constant at 38°F (Deitschman, 1974)
LIGHT: Better germination in light (Deitschman, 1974)
GERMINATIVE ENERGY: 90% in 60 days (Deitschman, 1974)
GERMINATIVE CAPACITY: 85% in 100 days (Deitschman, 1974)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Deitschman, 1974)
PLANTING TIME: Fall or winter (Deitschman, 1974); Spring (Stark, 1966)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Coarse to rocky (Sutton & Johnson, 1974)
SOIL pH: 6.5-7.5 (Sutton & Johnson, 1974)
SOIL DEPTH: Deep (Sutton & Johnson, 1974); 10-16" (Stark, 1966)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
PRECIPITATION: 8-14" (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Mulch with light straw (Deitschman, 1974)

ARTEMISIA SPINESCENS D. C. Eaton

(Bud Sagebrush)

FAMILY: Asteraceae
LIFEFORM: Native evergreen shrub 5-50 cm tall (Harrington, 1964)
FRUIT: A hairy achene (Stark, 1966) 1 mm long (Wood, 1966)

CULTURAL PRACTICES

EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Fine to medium (Stark, 1966)
SOIL pH: Alkali and saline tolerant (Stark, 1966); 7.8-9.7 (Wood, 1966)
SOIL DEPTH: Deep (Stark, 1966; Wood, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
PRECIPITATION: 6-10" (Stark, 1966)
FIELD PLANTING: Flowerheads fall entire, seeds germinate within the head in nature, soil must be wet for at least 30 days or seedlings will not survive (Wood, 1966)

ARTEMISIA TRIDENTATA TRIDENTATA Nutt.

(Big Sagebrush)

FAMILY: Asteraceae
LIFEFORM: Native evergreen shrub 40-400 cm tall (Harrington, 1964)
FRUIT: An achene, seeds are 0.69 x 1.43 mm in size and weigh approx 0.0002 g (Goodwin, 1956)

PROCUREMENT

SEEDS/LB: 2,383,000-3,238,000--avg 2,466,000 (Deitschman, 1974); 2,575,940 (Plummer et al., 1968)
SEED MATURITY: Nov 5-Jan 15 UT (Plummer et al., 1968); Oct 15-Dec 30 WA (Goodwin, 1956); Oct-Nov UT (Shepherd, 1937); Seed maturity has a large effect on germination characteristics, early maturing seeds germinate best (Goodwin, 1956)

METHOD OF COLLECTION: Shake, beat, or hand strip into shoulder hopper, baskets, or sack (Deitschman, 1974); Rub or strip into containers (Plummer et al., 1968)
METHOD OF CLEANING: Hammermill, fan and screen (Deitschman, 1974); Hammermill (Plummer et al., 1968)

PRETREATMENT

DURATION OF GOOD VIABILITY: 2 years (Deitschman, 1974; Hull, 1973; Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 36°F for 10 days (Deitschman, 1974; Stark, 1966); Moist chill at 1-3°C for 30-50 days (McDonough & Harniss, 1974a); Germinates well without stratification, germination increases and becomes more rapid with up to 60 day's moist chill at 3-5°C but decreases after 90 days moist chill, scarification in sulfuric acid for 1-2 minutes is detrimental (Goodwin, 1956); Stratification not necessary, germination improved by soaking seed in dilute (N/1000) hydrochloric acid (Shepherd, 1937)

LABORATORY GERMINATION

TEMPERATURE: Constant at 62-64°F (Deitschman, 1974); 20°C constant or alternating 20°C day and 2°C night (McDonough & Harniss, 1974a); 70°F (Weldon et al., 1959); 17-19°C (Goodwin, 1956)
MOISTURE: Moist (Weldon et al., 1959); Free water aids germination (Goodwin, 1956); Will germinate with as low as 2.5 atmospheres negative pressure (Choudhuri, 1968)
LIGHT: Better germination in light (Deitschman, 1974; Weldon et al., 1959; Goodwin, 1956; Shepherd, 1937)
GERMINATIVE ENERGY: 80% in 40 days (Deitschman, 1974); 27% in 9 days (Shepherd, 1937)
GERMINATIVE CAPACITY: 56-85% in 100 days (Deitschman, 1974); 56% (McDonough & Harniss, 1974a); 0-94% in 15 days (Payne, 1957); 55-75% (Goodwin, 1956); 32% (Swingle, 1939); 30% (Shepherd, 1937)
COMMENTS: Germination will occur under a wide range of temperature, moisture, and light conditions (Goodwin, 1956); 25°C temperature inhibits germination (Stark, 1966); Seed may be damaged by high heat but less so when seed is moist, natural germination rates are highly variable due to source and date of collection, seeds collected later in the season have slightly better germination (Payne, 1957)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Deitschman, 1974); Soil surface (Stark, 1966); 0-15 mm, will not emerge from 25 mm (Goodwin, 1956)
PLANTING TIME: Fall or winter (Deitschman, 1974); Spring (Stark, 1966); Fall or spring (Shepherd, 1937)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Coarse to fine (Sutton & Johnson, 1974)
SOIL pH: 6.5-7.5 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate to deep (Sutton & Johnson, 1974); 20-60+" (Stark, 1966)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
PRECIPITATION: 8+" (20 cm) (Sutton & Johnson, 1974); 8-14+" (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Mulch with light straw (Deitschman, 1974)
FIELD PLANTING: Thrives with added nitrogen and water (Stark, 1966); Field germination Feb 1-Apr 30 (Goodwin, 1956)

ARTEMISIA TRIDENTATA VASEYANA (Rydb.) Beetle
(Mountain Big Sagebrush)

FAMILY: Asteraceae
LIFEFORM: Native evergreen shrub 4.9-27.4 cm tall (Winward & Tisdale, 1977)
FRUIT: An achene, seeds weigh approx 0.000258 g (Winward & Tisdale, 1977)

PRETREATMENT

STRATIFICATION AND SCARIFICATION: Moist chill at 1-3°C for 40-50 days (McDonough & Harniss, 1974b)

LABORATORY GERMINATION

TEMPERATURE: Constant at 20°C or alternating at 20°C day and 2°C night (McDonough & Harniss, 1974a)
MOISTURE: Moist (McDonough & Harniss, 1974a)
LIGHT: Light has limited positive effect (McDonough & Harniss, 1974b)
GERMINATIVE CAPACITY: 94% in 30 days (McDonough & Harniss, 1974a&b)
COMMENTS: Both acid scarification and gibberellic acid promote germination (McDonough & Harniss, 1974b)

ATRIPLEX CANESCENS (Pursh) Nutt.
(Fourwing Saltbush)

FAMILY: Chenopodiaceae
LIFEFORM: Native shrub, 20-250 cm tall (Harrington, 1964)
FRUIT: A utricle with four wings 5-23 mm wide (Springfield, 1969)

PROCUREMENT

SEEDS/LB: Dewinged 13,000-148,000--avg 52,000, intact 22,500 (Foiles, 1974); Intact 7,800-54,900 (Springfield, 1969); 10,500-25,600 (Swingle, 1939)
SEED MATURITY: Oct (Foiles, 1974); Aug-Sep MT (Gamrath, 1972); Oct 20-Mar 1 UT (Plummer, et al., 1968); Late summer to fall (Swingle, 1939)

METHOD OF COLLECTION: Shake or hand strip seeds into bags, baskets, or onto canvas, also vacuum harvested (Foiles, 1974)
METHOD OF CLEANING: Hammermill and fan (Foiles, 1974; Plummer et al., 1968); Hammermill at 1,500 rpm with 1/4" wire mesh (Hervey & Boyd, 1953)

PRETREATMENT

METHOD OF STORAGE: Store in cloth bags in unheated warehouse (Foiles, 1974; Springfield, 1968c); Store in sealed containers at 70°F (Hervey & Boyd, 1953; King, 1947)
DURATION OF GOOD VIABILITY: 6-7 years (Foiles, 1974; Springield, 1968c); Retention of good viability may be influenced by the year seeds were collected (Springfield, 1968a); Hammermilling seed may increase duration of good viability (Hervey & Boyd, 1953); 5 years (King, 1947)
STRATIFICATION AND SCARIFICATION: 10 months afterripening at storage conditons (Foiles, 1974; Springfield, 1969); Germination energy and capacity improved by heavy scarification (Gerard, 1965; Nord & Whitacre, 1957); Soak seeds in sulfuric acid for 40 minutes (Gerard, 1965); Germination may be inhanced by leaching salts from seeds with water for 2 hours (Twitchell, 1955); Soak seeds in sulfuric acid for 60 minutes (Housley, 1952); Moist chill at 5°C for 12 weeks, dry storage negates stratification requirement (King, 1947)

LABORATORY GERMINATION

TEMPERATURE: California strain alternating 75°F day and 65°F night, New Mexico strain constant at 60-65°F, Utah strain alternating at 38°F day and 32°F night (Foiles, 1974)
MOISTURE: Moist (Aldon, 1970b; Hervey & Boyd, 1953); Lower moisture limit for germination 11 atmospheres of negative pressure, optimum moisture level 0 atmospheres (Springfield, 1969; Springfield, 1966); Best when relative humidity is 60-98% (Gerard, 1965)
LIGHT: Light neither necessary nor inhibitory (Springfield, 1969); Short periods of light and dark may inhibit germination (Gerard, 1965)
GERMINATIVE ENERGY: California strain 22% in 5 days, New Mexico strain 54-68% in 6-11 days, Utah strain 48% in 20 days (Foiles, 1974)
GERMINATIVE CAPACITY: California strain 44% in 30 days, New Mexico strain 70-94% in 30-34 days, Utah strain 53% in 50 days (Foiles, 1974); 20% in 7 days CA (Williams et al., 1974); 44% ID (King, 1947); 17% ID (Glazebrook, 1941); 22-43% (Swingle, 1939)
COMMENTS: Germinative characteristics vary with the seed source (Foiles, 1974; Gerard, 1965; Springfield, 1964); Smallest utricles have highest percentage of fill (Gamrath, 1972); High percentage of empty seeds, germination inhibited by deficient aeration (Springfield, 1969); Dewinging improves germination, chloride and other soluble minerals may inhibit germination, thiourea at 3% inhibits germination (Gerard, 1965); Tetrazolium staining works well to determine viability (Boyd, 1954); Potassium nitrate does not improve germination (Hervey & Boyd, 1953; Housley, 1952)

CULTURAL PRACTICES

PLANTING DEPTH: 1/2" (Foiles, 1974; Nord et al., 1971); Best emergence from 1 cm but will emerge from 2 cm (Williams et al., 1974); 1/2-1" (Springfield, 1969; Springfield & Bell, 1967); 0-1/2" (Cassady, 1937)
PLANTING TIME: Just prior to dependable moisture, fall or winter (Kay et al., 1977a): Usually spring or summer (Foiles, 1974); Spring (Stark, 1966)
EXPOSURE: Sun (Foiles, 1974); Sun or shade (Woodmansee, 1969); Sun or valley bottom (Stark, 1966)
SOIL TEXTURE: Medium to fine (Stark, 1966)
SOIL pH: High alkaline tolerance (Stark, 1966)
SOIL DEPTH: Deep (Stark, 1966)
SOIL MOISTURE: Dry slopes, flats, and washes (Stark, 1966)
PRECIPITATION: 6-10" or less (Stark, 1966)
ORGANIC MATTER: Best reproduction in mulch (Woodmansee, 1969)
GREENHOUSE PLANTING: Detailed vegetative propagation techniques (Wiesner & Johnson, 1977); Germinates well in vermiculite (Hervey & Boyd, 1953)
NURSERY PLANTING: Broadcast seed and cover with 1/8-1/4" sand then roll, seedlings susceptible to damping off, birds, and rodents (Foiles, 1974)
FIELD PLANTING: It is important to plant site adapted strains, mulching improves establishment (Foiles, 1974); Soil moisture should be at least 14% by weight or between 1/3 and 2 atmospheres tension (Aldon, 1972); 4-6 week old transplants in 2x2x3 plant bands have been successfully field planted (Aldon, 1970a&b); Natural germination is erratic and dependent upon adequate moisture and proper timing of precipitation (Woodmansee, 1969); Emergence and survival are reduced by high soil temperatures (Sosebee & Herbel, 1969; Sosebee, 1966); Seedlings are susceptible to frost (Stark, 1966)

ATRIPLEX CONFERTIFOLIA (Terr. & Frem.) Wats.
(Shadscale Saltbush)

FAMILY: Chenopodiaceae
LIFEFORM: Native shrub 20-100 cm tall (Harrington, 1964)
FRUIT: A utricle with foliose bracts 5-12 mm long (Blauer et al., 1976)

PROCUREMENT

SEEDS/LB: 29,500-126,000--avg 65,000 (Foiles, 1974); 64,920 (Plummer et al., 1968); 15,200 (Swingle, 1939)
SEED MATURITY: Oct-Nov UT (Foiles, 1974); Oct 15-May 1 UT (Plummer et al., 1968); Late summer (Swingle, 1939)
METHOD OF COLLECTION: Shake or hand strip into bags, basket, or onto canvas, also vacuum harvested (Foiles, 1974)
METHOD OF CLEANING: Hammermill, fan (Foiles, 1974); Fan (Plummer, et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store in cloth bags in unheated warehouse (Foiles, 1974)
DURATION OF GOOD VIABILITY: 6-7 years (Foiles, 1974); Less than 5 years (King, 1947)
STRATIFICATION AND SCARIFICATION: 6 months afterripening under storage conditions (Foiles, 1974); 3 months afterripening at 70°F (Hussain, 1966)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 38°F day and 32°F night (Foiles, 1974); Alternating at 85°F day and 65°F night (Hussain, 1966)
GERMINATIVE ENERGY: 12% in 365 days (Foiles, 1974)
GERMINATIVE CAPACITY: 25% in 1,460 days (Foiles, 1974); 1-5% (Hussain, 1966); 0-21% (Swingle, 1939)
COMMENTS: Will germinate in 1% salt solution but germinates best in 0% salt; seed viability varies with seed source (Hussain, 1966); Bracteoles enclosing seed will not permit germination, seed also contains a strong chemical germiation inhibitor which is water soluble (Vest & Cottam, 1953)

CULTURAL PRACTICES

PLANTING DEPTH: 1/2" (Foiles, 1974)
PLANTING TIME: Just prior to dependable moisture, usually spring or summer (Foiles, 1974; Kennedy, 1900)
SOIL TEXTURE: Medium to fine (Sutton & Johnson, 1974)
SOIL pH: 7.5-9.0 (Sutton & Johnson, 1974); high alkaline tolerance (Stark, 1966)
SOIL DEPTH: Deep to moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry (Stark, 1966); Should be moist for germination and establishment (Kennedy, 1900)
PRECIPITATION: 4-8" (10-20 cm) (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained, some periods of standing water (Sutton & Johnson, 1974), 25-60% saturation (Stark, 1966)
NURSERY PLANTING: Broadcast seed and cover with 1/8" soil and 1/4" sand then roll, seedlings susceptible to damping-off, birds, and rodents (Foiles, 1974)
FIELD PLANTING: Mulching usually improves establishment (Foiles, 1974); Bracteoles must be removed from seed and seeds leached with water before planting (Vest & Cottam, 1953); Use of containerized seedlings improves establishment (Kennedy, 1900)

ATRIPLEX CORRUGATA S. Wats. (Mat Saltbush)

FAMILY: Chenopodiaceae
LIFEFORM: Native half shrub 10-20 cm tall (Harrington, 1964)
FRUIT: A utricle with bracts 4-6 mm wide (Blauer et al., 1975)

PROCUREMENT

SEEDS/LB: 100,900 (Blauer et al., 1975)
SEED MATURITY: May 15-Aug 15 (Blauer et al., 1975)

CULTURAL PRACTICES

PLANTING DEPTH: Press into surface (Kennedy, 1900)
PLANTING TIME: Late spring or summer when ground is warm (Kennedy, 1900)
EXPOSURE: Sun (Blauer et al., 1975)
SOIL TEXTURE: Fine to medium (Blauer et al., 1975)
SOIL pH: Salt tolerant up to 13,000 ppm (Blauer et al., 1975)
SOIL MOISTURE: Dry (Blauer et al., 1975); Should be moist for germination and establishment (Kennedy, 1900)
FIELD NURSERY: Use of containerized seedlings will result in a more consistent establishment (Kennedy, 1900)

ATRIPLEX NUTTALLII S. Wats. (Nuttall Saltbush)

FAMILY: Chenopodiaceae
LIFEFORM: Native half shrub 20-50 cm tall (Harrington, 1964)
FRUIT: A utricle with several small bracts 4-7 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 100,000-119,000--avg 111,500 (Foiles, 1974); 65,908-91,980 (McLean, 1953)
SEED MATURITY: Nov-Dec UT (Foiles, 1974); Sep WY (Vosler, 1962)' Sep 25-Oct 14 CANADA (McLean, 1953)
METHOD OF COLLECTION: Shake or hand strip into bags, basket, or onto canvas; also vacuum harvested (Foiles, 1974)
METHOD OF CLEANING: Hammermill and fan (Foiles, 1974)

PRETREATMENT

METHOD OF STORAGE: Store in cloth bags in unheated warehouse (Foiles, 1974)

DURATION OF GOOD VIABILITY: 6-7 years (Foiles, 1974)
STRATIFICATION AND SCARIFICATION: 3 months afterripening under storage conditions (Foiles, 1974); Moist chill at 5°C for 4 days (McLean, 1953)

LABORATORY GERMINATION

TEMPERATURE: Utah strain alternating at 38°F day and 32°F night (Foiles, 1974); Alternating at 30°C day and 20°C night (McLean, 1953)
MOISTURE: Moist (McLean, 1953)
GERMINATIVE ENERGY: 28% in 60 days (Foiles, 1974); 6-40% in 30 days (Vosler, 1962); 40% in 6 days (McLean, 1953)
GERMINATIVE CAPACITY: 36% in 150 days (Foiles, 1974); 6.2-61% in 21 days (McLean, 1953); 65% (Swingle, 1939)
COMMENTS: High concentrations of NaOH have little effect on germination (Vosler, 1962); Only 25% of the seed collected contained viable embryos, germination ability varies widely with seed source (McLean, 1953); Seeds heavily attacked by insect larvae (McLean, 1953)

CULTURAL PRACTICES

PLANTING DEPTH: 1/2" (Foiles, 1974; Nelson, 1904); Shallow or at surface, emergence decreases rapidly below 1/2" (McLean, 1953)
PLANTING TIME: Just prior to dependable moisture, usually spring or summer (Foiles, 1974); Spring (McLean, 1953); Spring, soil should be warm (Kennedy, 1900)
EXPOSURE: Sun (Foiles, 1974; Stark, 1966)
SOIL TEXTURE: Coarse to medium on poorly developed soils (Stark, 1966); Medium to fine textured, no real textural preference (Vosler, 1962); Mostly heavy, fine textured soils (McLean, 1953)
SOIL pH: High alkaline tolerance, slight saline-alkaline tolerance (Stark, 1966); 6.6-8.1, 0.29-3.468% soluble salt (McLean, 1953)
SOIL DEPTH: Deep, 36-60+" (Stark, 1966; McLean, 1953)
SOIL MOISTURE: Dry hills (Stark, 1966); Moist for germination and establishment (Nelson, 1904)
PRECIPITATION: 4-10" (Stark, 1966)
NURSERY PLANTING: Broadcast seed and cover with 1/8" soil and 1/4" sand then roll, seedlings susceptible to damping-off, birds, and rodents (Foiles, 1974)
FIELD PLANTING: Mulching improves establishment (Foiles, 1974); Use of containerized seedlings improves establishment (Kennedy, 1900)

ATRIPLEX NUTTALLII CUNEATA (Nelson) H. & C.
(Castlevalley Clover Saltbush)

SYNONOMY: *Atriplex nuttallii, Atriplex cuneata*
FAMILY: Chenopodiaceae
LIFEFORM: Native half shrub 20-50 cm tall (Harrington, 1964)
FRUIT: A utricle with bracts 5-9 mm wide (Blauer et al., 1976)

PROCUREMENT

SEEDS/LB: 81,660 (Blauer et al., 1976)
SEED MATURITY: Jun 1-Aug 20 UT (Blauer et al., 1976)
METHOD OF CLEANING: Hammermill and fan (Blauer et al., 1976)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 42% (Swingle, 1939)

CULTURAL PRACTICES

PLANTING DEPTH: Press seed into surface (Kennedy, 1900)
PLANTING TIME: Late spring or summer when ground is warm (Kennedy, 1900)
SOIL pH: Highly alkali tolerant (Kennedy, 1900)
SOIL MOISTURE: Moist for germination and establishment (Kennedy, 1900)
FIELD PLANTING: Use of containerized seedlings improves establishment (Kennedy, 1900)

ATRIPLEX NUTTALLII GARDNERI
(Moq.) Hull & Clements
(Gardner Saltbush)

SYNONOMY: *Atriplex nuttallii, Atriplex gardneri*
FAMILY: Chenopodiaceae
LIFEFORM: Native half shrub 20-50 cm tall (Harrington, 1964)
FRUIT: A utricle with bracts 3-6 mm long (Blauer et al., 1976)

PROCUREMENT

SEEDS/LB: 111,450 (Plummer et al., 1968)
SEED MATURITY: Sep 10-Mar 1 UT (Plummer et al., 1968)
METHOD OF CLEANING: Fan (Plummer et al., 196

PRETREATMENT

DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968)

LABORATORY GERMINATION

TEMPERATURE: Constant at 60-65°F (Nord et al 1971)
GERMINATIVE CAPACITY: 10% (Nord et al., 197

CULTURAL PRACTICES

PLANTING DEPTH: 1/2" (Nord et al., 1971)

PLANTING TIME: Late spring or summer when ground is warm (Kennedy, 1900)

SOIL TEXTURE: Fine (Blauer et al., 1976)

SOIL SALINITY: Up to 5,500 ppm salt (Blauer et al., 1976)

SOIL MOISTURE: Dry (Blauer et al., 1976); Moist for germination and establishment (Kennedy, 1900)

FIELD PLANTING: Use of containerized seedlings improves establishment (Kennedy, 1900)

ATRIPLEX OBOVATA Moq.
(Broadscale Saltbush)

FAMILY: Chenopodiaceae

LIFEFORM: Native half shrub 20-50 cm tall (Harrington, 1964)

FRUIT: A utricle with bracts 5-9 mm broad (Blauer et al., 1975)

SEED: 1-5 mm wide (Edgar & Springfield, 1977)

PROCUREMENT

SEEDS/LB: 207,630 (Blauer et al., 1975)

SEED MATURITY: Aug 20-Sep 20 UT (Blauer et al., 1975)

PRETREATMENT

STRATIFICATION AND SCARIFICATION: Afterripen at 23°C for 3 1/2 months (Edgar & Springfield, 1977)

LABORATORY GERMINATION

TEMPERATURE: Constant at 20°C (Edgar & Springfield, 1977)

LIGHT: Best in continuous light but a brief daily exposure is adequate to promote germination (Edgar & Springfield, 1977)

GERMINATIVE ENERGY: 8-38% in 3 days (Edgar & Springfield, 1977)

GERMINATIVE CAPACITY: 10-48% in 13 days (Edgar & Springfield, 1977)

COMMENTS: Germination rate promoted by: thiourea and dusting with activated charcoal (Edgar & Springfield, 1977; Kay, 1974); Potassium nitrate and stratification (Edgar & Springfield, 1977; Blauer et al., 1975); Soaking in water (Edgar & Springfield, 1977); Scarification (Edgar & Springfield, 1977); Gibberillic acid (Edgar & Springfield, 1977)

CULTURAL PRACTICES

PLANTING DEPTH: Press into surface (Kennedy, 1900)

PLANTING TIME: Spring (Edgar & Springfield, 1977); Spring or summer when ground is warm (Kennedy, 1900)

EXPOSURE: Sun (Blauer et al., 1975)

SOIL TEXTURE: Coarse (Blauer et al., 1975)

SOIL pH: Found on alkaline soils (Edgar & Springfield, 1977)

SOIL SALINITY: Found on saline soils (Edgar & Springfield, 1977); 165-4,900 ppm salt (Blauer et al., 1975)

SOIL MOISTURE: Dry (Blauer et al., 1975); Moisture for germination and establishment (Kennedy, 1900)

FIELD PLANTING: Use of containerized seedlings improves establishment (Kennedy, 1900)

BACCHARIS EMORYI A. Gray
(Emory Baccharis)

FAMILY: Asteraceae

LIFEFORM: Native evergreen shrub 1-4 m tall (Harrington, 1964)

FRUIT: An achene (Harrington, 1964)

PRETREATMENT

STRATIFICATION AND SCARIFICATION: None necessary (Swingle, 1939)

CULTURAL PRACTICES

PLANTING TIME: Fall or spring (Swingle, 1939)

EXPOSURE: Sun (Stark, 1966)

SOIL TEXTURE: Medium (Stark, 1966)

SOIL SALINITY: Often in saline soil (Harrington, 1964)

SOIL DEPTH: Deep (Stark, 1966)

SOIL MOISTURE: Moist (Stark, 1966)

SOIL DRAINAGE: Well-drained (Stark, 1966)

BACCHARIS GLUTINOSA Pursh
(Seep-willow)

FAMILY: Asteraceae

LIFEFORM: Native evergreen shrub 3-12 ft tall (Vines, 1960)

FRUIT: An achene (Vines, 1960)

PRETREATMENT

METHOD OF STORAGE: Store dry at 40°F (Horton et al., 1960)

DURATION OF GOOD VIABILITY: Up to 1 year at 70°F and up to 2 years at 40°F (Horton et al., 1960)

STRATIFICATION AND SCARIFICATION: None necessary (Swingle, 1939)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 26-45% (Horton et al., 1960)

COMMENTS: Seed germination unsuccessful (Stark, 1966); Germination highly variable (Horton et al., 1960)

CULTURAL PRACTICES

PLANTING TIME: Fall or spring (Swingle, 1939)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Fine (Stark, 1966)
SOIL pH: Alkali tolerant (Stark, 1966)
SOIL MOISTURE: Moist (Stark, 1966); Usually along stream banks (Vines, 1960)
DRAINAGE: Well-drained (Stark, 1966)
FIELD PLANTING: Reproduces well from cuttings (Vines, 1960)

BERBERIS VULGARIS L. (Common Barberry)

FAMILY: Berberidaceae
LIFEFORM: Introduced shrub to 2.5 m tall (Harrington, 1964)
FRUIT: A few-seeded berry 8-12 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 41,215 (Swingle, 1939)
SEED MATURITY: Late fall (Swingle, 1939)

PRETREATMENT

METHOD OF STORAGE: Dry (Swingle, 1939)
STRATIFICATION AND SCARIFICATION: Sow in soil over winter (Adams, 1927)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 86% in 295 days (Adams, 1927)

CULTURAL PRACTICES

PLANTING TIME: Fall or spring (Swingle, 1939); Fall (Adams, 1927)

BRICKELLIA CALIFORNICA (T. & G.) Gray (California Brickellia)

FAMILY: Asteraceae
LIFEFORM: Native shrub 25-100 cm tall (Harrington, 1964)
FRUIT: An achene (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 599,000 (Mirov & Kraebel, 1939; Swingle, 1939)
SEED MATURITY: Aug-Oct CA (Mirov & Kraebel, 1939; Swingle, 1939)

PRETREATMENT

STRATIFICATION AND SCARIFICATION: No treatment necessary (Mirov & Kraebel, 1939; Swingle, 1939)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 36% in 3 days (Mirov & Kraebel, 1939)
COMMENTS: Has been successfully germinated (Stark, 1966)

CULTURAL PRACTICES

EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Fine to coarse (Stark, 1966)
SOIL DEPTH: Moderate to deep (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)

CEANOTHUS FENDLERI A. Gray (Fendler Ceanothus)

FAMILY: Rhamnaceae
LIFEFORM: Native shrub 20-80 cm tall (Harrington, 1964)
FRUIT: A 3-lobed capsule 4-5 mm wide (Harrington, 1964)

PROCUREMENT

SEED MATURITY: Aug-Dec AZ (Reed, 1974)
METHOD OF COLLECTION: Only from vigorous plants, tie cloth bags over green seed pod clusters until seed is ejected (Reed, 1974)
METHOD OF CLEANING: Screen and fan (Reed, 1974)

PRETREATMENT

METHOD OF STORAGE: Sealed containers at 40°F (Reed, 1974)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 16% (Reed, 1974; Swingle, 1939)

CULTURAL PRACTICES

PLANTING DEPTH: Twice the greatest diameter of seed (Reed, 1974)
PLANTING TIME: Spring (Reed, 1974)
EXPOSURE: Sun or shade (Sutton & Johnson, 1974)
SOIL TEXTURE: Light (Reed, 1974); Medium to coarse (Sutton & Johnson, 1974)
SOIL pH: 6.0-7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Shallow to moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Reed, 1974; Sutton & Johnson, 1974)
GREENHOUSE PLANTING: Sensitive to damping-off (Reed, 1974)

CEANOTHUS MARTINII M. E. Jones (Martin Ceanothus)

FAMILY: Rhamnaceae
LIFEFORM: Native evergreen shrub 1-2 ft tall (Sutton & Johnson, 1974)
FRUIT: A three-lobed capsule (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 82,845 (Plummer et al., 1968)
SEED MATURITY: Jul 10-Aug 15 (Plummer et al., 1968)
METHOD OF COLLECTION: Handpick into containers (Plummer et al., 1968)
METHOD OF CLEANING: Dry, fan, and float then fumigate (Plummer et al., 1968)

PRETREATMENT

DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968)

CULTURAL PRACTICES

EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium (Sutton & Johnson, 1974)
SOIL pH: 6.5 (Sutton & Johnson, 1974)
SOIL DEPTH: Deep (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)

CEANOTHUS VELUTINUS Dougl. (Snowbrush Ceanothus)

FAMILY: Rhamnaceae
LIFEFORM: Native shrub 1-3 m tall (Harrington, 1964)
FRUIT: A three-lobed capsule 3-6 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 61,400-152,000--avg 94,000 (Reed, 1974); 124,275 (Plummer et al., 1968); 71,000 (Swingle, 1939)
SEED MATURITY: Aug UT; Jul-Sep OR; Aug 10-Sep 10 MT; Jul 15-Aug 1 ID (Reed, 1974); Aug 1-Aug 30 UT (Plummer et al., 1968); Jul-Aug NV (Stark, 1966); Jul-Aug (Swingle, 1939)
METHOD OF COLLECTION: Only from vigorous plants, tie cloth bags over green seed pod clusters until seed is ejected (Reed, 1974); Handpick seed into containers (Plummer et al., 1968)
METHOD OF CLEANING: Screen and fan (Reed, 1974); Dry, fan, and float (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Sealed containers at 40°F (Reed, 1974)
DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968); 12 years (Quick & Quick, 1961)
STRATIFICATION AND SCARIFICATION: Hot water soak to 194°F then cool or moist chill at 34-41°F for 63-84 days (Reed, 1974); Hot water soak 80-85 minutes or soak in sulfuric acid for 30-60 minutes then moist chill at 3-5°C for 2 months (Heit, 1970); Moist chill at 34-41°F for 63-84 days, scarification may be beneficial (Peterson, 1953); Hot water soak and moist chill for 3 months (Swingle, 1939; Mirov & Kraebel, 1937); Hot water soak at 80°C, cool, then moist chill at 2.5°C for 90 days (Quick, 1935)

LABORATORY GERMINATION

TEMPERATURE: Alternating 30°C day and 20°C night (Heit, 1970)
GERMINATIVE ENERGY: 9% in 22 days (Peterson, 1953)
GERMINATIVE CAPACITY: 82% (Reed, 1974); 79% in 7 days (Heit, 1970); 11% in 35 days (Peterson, 1953); 68% (Swingle, 1939); 68% in 100 days (Mirov & Kraebel, 1937); 68% in 14 days (Quick, 1935)
COMMENTS: Germination may be enhanced by fire in nature (Curtis, 1952)

CULTURAL PRACTICES

PLANTING DEPTH: Twice the greatest diameter of seed (Reed, 1974)
PLANTING TIME: Fall (Heit, 1970); Summer (Stark, 1966)
EXPOSURE: Sun (Sutton & Johnson, 1974; Stark, 1966)
SOIL TEXTURE: Medium to coarse (Sutton & Johnson, 1974)
SOIL pH: 5.5-7.0 (Sutton & Johnson, 1974); Near acid (Stark, 1966)
SOIL DEPTH: Deep (Sutton & Johnson, 1974); 20-60+" (Stark, 1966)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
PRECIPITATION: 10-14+" (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)
GREENHOUSE PLANTING: Sensitive to damping-off (Reed, 1974)
NURSERY PLANTING: Vegetative propagation with 2-3" branch tips in a frame with bottom heat, use root producing hormone (Mirov & Kraebel, 1939)
FIELD PLANTING: Minimum soil temperature for germination 45-65°C and optimum of 80-105°C with lethal at approx 120°C in nature (Gratkowski, 1962)

CERATOIDES LANATA (Pursh) J. T. Howell (Winterfat)

SYNONOMY: *Eurotia lanata*
FAMILY: Chenopodiaceae
LIFEFORM: Native shrub 30-100 cm tall (Harrington, 1964)

FRUIT: A one-seeded utricle with bracts 4-8 mm long (Harrington, 1964)

SEED: A nutlet enclosed in two bracts with fluffy white ahirs (Springfield, 1974a)

PROCUREMENT

SEEDS/LB: 126,000-210,000 (Eddleman, 1977); 111,000-208,000 (Springfield, 1974a); 112,275 (Plummer et al., 1968); 54,400 (Swingle, 1939)

SEED MATURITY: Sep 30-Nov 11 MT (Eddleman, 1977); Oct 15-Nov 15 (Springfield, 1974a); Oct 5-Dec 30 UT (Plummer et al., 1968); Late summer (Swingle, 1939)

METHOD OF COLLECTION: Head cutter (Eddleman, 1977); Hand strip (Stevens et al., 1977); Hand strip or use vacuum harvester (Springfield, 1974a); Hand strip or use seed strippers (Plummer et al., 1968);

METHOD OF CLEANING: Hammermill with 5/16" screen at 1,000-1,200 rpm (Stevens et al., 1977); Removal of seed from hairy utricle not advised (Hodgkinson, 1975); Hammermill at 850 rpm, fan with 7/64" upper screen and 1/16" lower screen (Springfield, 1974a); Hammermill (Hilton, 1941)

PRETREATMENT

METHOD OF STORAGE: Do not remove seeds from bracts (Stevens et al., 1977); Store at 40°F in sealed containers (Springfield, 1974a); In sealed containers at 34-42°F (Springfield, 1974b; Srpingfield, 1968b; Workman & West, 1967); No advantage to cold storage (Housley, 1952)

DURATION OF GOOD VIABIITY: 8 years at 34-42°F (Springfeild, 1974b); 1 year (Plummer et al., 1968)

STRATIFICATION AND SCARIFICATION: Should undergo short period of cool or freezing temperature before or after harvest Stevens et al., 1977); Afterripen 9-13 weeks from collection for best germination (Springfield, 1972b)

LABORATORY GERMINATION

TEMPERATURE: Best at a constant 10°C (Moyer & Lang, 1976); Alternating 86°F day and 68°F night (Springfield, 1974a); Constant between 50-80°F (Springfield, 1972a); Constant between 55-75°F (Springfield, 1969); Constant between 42-72°F (Hilton, 1941)

MOISTURE: Best germination in moist environment (Hodgkinson, 1975; Springfield, 1968d); Germination decreases as moisture stress increases (Springfield, 1974a, 1971, 1968d; Al-Rabbat, 1962); Ability to withstand moisture stress increases as temperature decreases; lower limit of germination is at -15 atmospheres of moisture stress (Springfield, 1968d)

LIGHT: Light is neither necessary nor inhibitory (Springfield, 1974a; Hilton, 1941)

GERMINATIVE ENERGY: 8-42% in 6 days (Moyer & Lang, 1976); 93% in 5 days (Springfield, 1974a)

GERMINATIVE CAPACITY: 18-65% in 15 days (Moyer & Lang, 1976); 94-100% in 5 days (Hodgkinson, 1975); 94% in 29 days (Springfield, 1974a); 83% in 5 days (Al-Rabbat, 1962); 72-86% (Swingle, 1939)

COMMENTS: Stratification requirements and temperature requirements may vary with seed source (Moyer & Lang, 1976); Large--2.9-3.6 mm long--and medium--2.5-3.1 mm long--sized seeds germinate better and faster than small--2.0-2.6 mm long--seed (Springfield, 1973b); Chloride salts cause greater reduction in germination than sulfate salts (Clark & West, 1971); Upper salt concentration for germination approx 2% (Clark & West, 1971; Hilton, 1941); Upper salt concentration for germination 3% (Workman & West, 1969); No benefit from potassium nitrate (Housley, 1952)

CULTURAL PRACTICES

PLANTING DEPTH: 1/16-1/4" (Stevens et al., 1977); 1/16-1/8" (Springfield, 1974a); 1/16" (Springfield, 1971); On or near surface when soil moisture is over field capacity (Springfield, 1970a; Al-Rabbat, 1962); 1/4" (Statler, 1967); Will not emerge below 1/2", seedling mortality greatest at surface planting (Al-Rabbat, 1962)

PLANTING TIME: Late fall-early winter (Hodgkinson, 1975); Spring (Statler, 1967); Variable (Stark, 1966)

EXPOSURE: Intolerant to shade, best in sun (Woodmansee & Potter, 1971)

SOIL TEXTURE: Loamy soils (Stark, 1966)

SOIL pH: 7.4-8.0 (Woodmansee & Potter, 1971); Subalkaline (Stark, 1966)

SOIL DEPTH: Deep, 36-60" (Stark, 1966)

PRECIPITATION: 6-19" (Stark, 1966)

ORGANIC MATTER: Best reproduction in mulch (Woodmansee & Potter, 1971; Woodmansee, 1969)

DRAINAGE: Well-drained (Stark, 1966)

FIELD PLANTING: Exhibits strong ecotype variation, seedling vigor varies with seed source, tall-growing strains best suited for winter ranges, seeds should be sown in cool weather (Springfield, 1974a); Sensitive to deficient aeration (Springfield, 1971): Tolerant to competition (Woodmansee & Potter, 1971); Tolerance of seeds to NaCl during germination varies with the seed source (Workman & West, 1969, 1967); Compaction before planting increases emergence, increasing depth from 0-1/2" delays emergence 2-3 days, moisture stress had little effect on emergence (Al-Rabbat, 1962)

CERCOCARPUS INTRICATUS S. Wats.
(Littleleaf Mountain Mahogany)

FAMILY: Rosaceae

LIFEFORM: Native evergreen shrub 30-150 cm tall (Harrington, 1964)

FRUIT: An achene (6-7 mm long) with a hairy style (2-4 cm long) (Harrington, 1964)

PROCUREMENT

SEED MATURITY: Jul 10-Jul 25 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Knock from bushes into hopper (Plummer et al., 1968)
METHOD OF CLEANING: Hammermill, fan, Dybvig, dry, and fan (Plummer et al., 1968)

PRETREATMENT

DURATION OF GOOD VIABILITY: 10 years (Plummer et al., 1968)

CULTURAL PRACTICES

EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium to coarse (Sutton & Johnson, 1974); Crevices in limestone (Stark, 1966)
SOIL pH: 7.0-7.5 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)

CERCOCARPUS LEDIFOLIUS Nutt. ex T. & G.
(Curlleaf Mountain Mahogany)

FAMILY: Rosaceae
LIFEFORM: Native shrub to small tree 7-8 m tall (Harrington, 1964)
FRUIT: An achene (8-10 mm long) with a hairy style (4-7 mm long) (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 48,200-56,600--avg 51,900 (Deitschman et al., 1974a); 50,600 (Glazebrook, 1941); 42,000 (Swingle, 1939; Mirov & Kraebel, 1937)
SEED MATURITY: Aug-Sep (Deitschman et al., 1974a); Jul 10-Sep 1 UT (Plummer et al., 1968); May-Jun (Swingle, 1939); May-Jun CA (Mirov & Kraebel, 1937)
METHOD OF COLLECTION: Shake branches onto canvas or into hopper (Plummer et al., 1968)
METHOD OF CLEANING: Hammermill, fan, and screen (Deitschman et al., 1974a); Hammermill, fan, Dybvig, dry, and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Dry storage in ventilated containers in unheated warehouse (Deitschman et al., 1974a)
DURATION OF GOOD VIABILITY: 5 years (Deitschman et al., 1974a); 10 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Germination may be improved by a 20 minute soak in sulfuric acid and then soaked in 3% thiourea for 16 hours followed by moist chilling at 32-38°F for 36 days or at 41°F for 30-90 days (Deitschman et al., 1974a); Soak in sulfuric acid for 20 minutes (Heit, 1970); Germination inhanced by 5 minute soak in sulfuric acid followed by a 4 hour soak in 3% thiourea (Liacos & Nord, 1961); Crack seed and then moist chill at 5°C for 12 weeks (Glazebrook, 1941)

LABORATORY GERMINATION

TEMPERATURE: Constant at 32-38°F (Deitschman et al., 1974a); Alternating at 30°C day and 10°C night (Heit, 1970, 1968)
LIGHT: Does not require light (Heit, 1968)
GERMINATIVE CAPACITY: 29-80% in 263-365 days (Deitschman et al., 1974a); 87% in 27 days (Heit, 1970); 44% (Swingle, 1939); 44% in 163 days (Mirov & Kraebel, 1937)
COMMENTS: Dormancy may vary with ecotypes (Deitschman et al., 1974a); No significant increase in germination from addition of thiourea or potassium nitrate (Heit, 1970)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-1/2" (Deitschman et al., 1974a)
PLANTING TIME: Fall (Deitschman et al., 1974a); December (Stark, 1966)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Coarse to rocky (Sutton & Johnson, 1974); Sandy loam (Stark, 1966)
SOIL pH: Near acid soils (6.0-7.0) (Sutton & Johnson, 1974)
SOIL DEPTH: 20-60" (Sutton & Johnson, 1974); Deep to shallow (Stark, 1966)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
PRECIPITATION: 12+" (30.5+ cm) (Sutton & Johnson, 1974)
ORGANIC MATTER: No (Stark, 1966)
DRAINAGE: Well-drained (Stark, 1966)
NURSERY PLANTING: Seedbed should be kept moist until germination (Deitschman et al., 1974a)
FIELD PLANTING: Mulch (Deitschman et al, 1974a)

CERCOCARPUS MONTANUS Raf.
(True Mountain Mahogany)

FAMILY: Rosaceae
LIFEFORM: Native shrub up to 3 m tall (Harrington, 1964)
FRUIT: An achene (8-10 mm long) with a hairy style (6-10 cm long) (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 55,900-65,200--avg 59,000 (Deitschman et al., 1974a); 28,000-41,000 (Piatt, 1973); 41,600-42,000 (Swingle, 1939)
SEED MATURITY: Aug-Sep (Deitschman et al., 1974a); Sep 15-Oct 5 CO (Smith & Bass, 1973); Jul 15-Sep 1 UT (Plummer et al., 1968); Summer (Swingle, 1939)
METHOD OF COLLECTION: Shake onto canvas or into hopper (Deitschman et al., 1974a); Collect achenes in years when precipitation during the growing season is average

or above, germination rates may be 2-3 times higher in wet than dry years, northerly aspects are the most desirable exposures, largest and most viable achenes may be found on less fertile soils where mountain mahogany plants are not abundant (Smith & Bass, 1973; Smith, 1971)

METHOD OF CLEANING: Hammermill, fan, and screen (Deitschman et al., 1974a); Hammermill, fan, Dybvig, dry, and fan (Plummer et al., 1968); Hammermill at 1080 rpm with 3/16" screen mesh (Hervey & Boyd, 1953)

PRETREATMENT

METHOD OF STORAGE: Sealed container in refrigerator (Smith & Bass, 1973); Sealed container in refrigerator or freezer (Springfield, 1973a); Sealed container in refrigerator (Smith, 1941); Sealed container at 70°F (Hervey, 1955; Hervey & Boyd, 1953)

DURATION OF GOOD VIABILITY: 5 years (Deitschman et al., 1974a); 7 years (Smith & Bass, 1973); Year of collection may influence duration of good viability (Smith, 1971); 10 years (Plummer et al., 1968); Hammermilling seed reduces duration of good viability (Hervey & Boyd, 1953)

STRATIFICATION AND SCARIFICATION: Germination may be improved by a 20 minute soak in sulfuric acid and a soak in 3% thiourea for 16 hours then moist chill at 32-38°F for 36 days or at 41°F for 30-90 days (Deitschman et al., 1974a); Afterripen at 20°C for 5 months then at 5°C for 6 weeks then moist chill at 5°C for 2-3 weeks (Smith & Bass, 1973; Smith, 1971); Germination improved by a 10 minute soak in sulfuric acid (Heit, 1970); Germination may be improved by leaching with water (Moore, 1963); Germination improved by a 60 minute soak in sulfuric acid but not as well as by moist chilling seed at 31-41°F for 35-70 days (Boyd, 1954)

LABORATORY GERMINATION

TEMPERATURE: Constant at 20°C (Piatt, 1976); Constant at 32-38°F (Deitschman et al., 1974a); Alternating at 30°C day and 20°C night (Smith & Bass, 1973; Smith, 1971; Heit, 1970); Constant at 54-57°F (Springfield, 1973a)

MOISTURE: Best in saturated state, lower limit of moisture stress negative 7 bars, moisture stress more inhibitory at non-optimal temperature (Piatt, 1976)

LIGHT: Neither positively nor negatively affected by light (Piatt, 1976)

GERMINATIVE CAPACITY: 82-88% in 28 days (Piatt, 1976); 92% in 70 days (Deitschman et al., 1974a); 28% in 15 days (Heit, 1970); 3-62% (Swingle, 1939); 65% (Griswald, 1936)

COMMENTS: Temperature and moisture relations may vary with seed source (Piatt, 1976); Dormancy may vary with ecotypes (Deitschman et al., 1974a); Total germination may vary with seed source, large seeds germinate better (Piatt, 1973); Potassium nitrate does not improve germination (Heit, 1970; Hervey & Boyd, 1953; Housley, 1952); Thiourea does not improve germination (Heit, 1970); Contains a water soluble germination inhibitor in the seed coat (Moore, 1963); Tetrazolium staining not satisfactory for determining viability (Boyd, 1954)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-1/2" (Deitschman et al., 1974a)

PLANTING TIME: Fall (Deitschman et al., 1974a)

EXPOSURE: Sun (Sutton & Johnson, 1974); Seedlings need shade for survival (Woodmansee, 1969; Hervey, 1955)

SOIL TEXTURE: Coarse to rocky (Sutton & Johnson, 1974)

SOIL pH: 6.5-7.5 (Sutton & Johnson, 1974)

SOIL DEPTH: Deep (Sutton & Johnson, 1974)

SOIL MOISTURE: Dry (Sutton & Johnson, 1974)

ORGANIC MATTER: No (Sutton & Johnson, 1974); Best reproduction in mulch (Woodmansee, 1969; Hervey, 1955)

DRAINAGE: Well-drained (Sutton & Johnson, 1974)

GREENHOUSE PLANTING: Reproduces well by cuttings (Swingle, 1939)

NURSERY PLANTING: Seedbed should be kept moist until germination (Deitschman et al., 1974a)

FIELD PLANTING: Mulch (Deitschman et al., 1974a); Natural reproduction erratic, dependent upon adequate moisture and proper timing of precipitation (Woodmansee, 1969)

CHRYSOTHAMNUS NAUSEOSUS (Pall.) Britt.
(Rubber Rabbitbrush)

FAMILY: Asteraceae

LIFEFORM: Native shrub 20-200 cm tall (Harrington, 1964)

FRUIT: An achene (5-5.5 mm long) with a pappus of hairs of the same length (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 445,000-483,000 (Eddleman, 1977); 649,000-745,000--avg 693,000 (Deitschman et al., 1974b); 335,000 (Mirov & Kraebel, 1937)

SEED MATURITY: Oct 15-Dec 30 UT (Plummer et al., 1968); Oct-Nov CA (Mirov & Krabel, 1937)

METHOD OF COLLECTOIN: Shake or strip heads into container or onto canvas, or vacuum harvest (Deitschman et al., 1974b; Plummer et al., 1968)

METHOD OF CLEANING: Mechanical flail, clipper (1/13)/blank, seed blower (Eddleman, 1977); Hammermill (Deitschman et al., 1974b; Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store dry in cloth bags in unheated warehouse (Deitschman et al., 1974b)
DURATION OF GOOD VIABILITY: 2 years (Deitschman et al., 1974b; Plummer et al., 1968)

LABORATORY GERMINATION

TEMPERATURE: Constant at 20°C (Eddleman, 1977); Constant at 33-38°F (Deitschman et al., 1974b)
GERMINATIVE ENERGY: 50% in 2-4 days (Eddleman, 1977); 38% in 21 days (Deitschman et al., 1974b)
GERMINATIVE CAPACITY: 94-99% (Eddleman, 1977); 63% in 120 days (Deitschman et al., 1974b); 36% in 3 days (Mirov & Kraebel, 1937)

CULTURAL PRACTICES

PLANTING TIME: Fall or winter (Deitschman et al., 1974b); Nov (Stark, 1966)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Sandy to clay loam (Stark, 1966)
SOIL pH: 7.0-8.5 (Stark, 1966)
SOIL SALINITY: Saline tolerant (Stark, 1966)
SOIL DEPTH: Moderate (40-60+") (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966); Phreatophytic (Stark, 1966)
PRECIPITATION: 6-10" (15-25 cm) (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)

CHRYSOTHAMNUS VISCIDIFLORUS (Hook.) Nutt.
(Douglas Rabbitbrush)

FAMILY: Asteraceae
LIFEFORM: Native shrub 10-240 cm tall (Harrington, 1964)
FRUIT: An achene 3-4 mm long with a pappus of hairs of the same length (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 674,000-840,000--avg 782,000 (Deitschman et al., 1974b)
SEED MATURITY: Fall, winter UT (Sutton & Johnson, 1974); Oct-Dec NV (Stark, 1966)
METHOD OF COLLECTION: Shake branches or strip heads into container or onto canvas, or vacuum harvest (Deitschman et al., 1974b)
METHOD OF CLEANING: Hammermill (Deitschman et al., 1974b)

PRETREATMENT

METHOD OF STORAGE: Store in cloth bags in unheated warehouse (Deitschman et al., 1974b)
DURATION OF GOOD VIABILITY: 2 years (Deitschman et al., 1974b)

LABORATORY GERMINATION

TEMPERATURE: Constant at 20-30°C (Eddleman, 1977); Constant at 33-38°F (Deitschman et al., 1974b); Alternating at 22°C day and 17°C night (McDonough, 1969)
LIGHT: Light may be beneficial (Eddleman, 1977)
GERMINATIVE ENERGY: 50% in 2-3 days (Eddleman, 1977); 49% in 7 days (McDonough, 1969)
GERMINATIVE CAPACITY: 92-97% (Eddleman, 1977); 60% in 300 days (Deitschman et al., 1974b); 98% in 28 days (McDonough, 1969)

CULTURAL PRACTICES

PLANTING TIME: Fall or winter (Deitschman et al., 1974b)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium to fine (Sutton & Johnson, 1974)
SOIL pH: 7.0-8.5 (Sutton & Johnson, 1974)
SOIL SALINITY: Salt tolerant (Stark, 1966)
SOIL DEPTH: Deep (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)

CHRYSOTHAMNUS VISCIDIFLORUS LANCEOLATUS
(Nutt.) H. & C.
(Mountain Low Rabbitbrush)

FAMILY: Asteraceae
LIFEFORM: Native shrub 20-50 cm tall (Harrington, 1964)
FRUIT: An achene 3-4 mm long (Harrington, 1964)

LABORATORY GERMINATION

TEMPERATURE: Constant at 70°F (Griswald, 1936)
MOISTURE: Moist (Griswald, 1936)
GERMINATIVE CAPACITY: 86% in 49 days (Griswald, 1936)
COMMENTS: Alternating moistening and drying of seed reduces germination (Griswald, 1936)

CLEMATIS LIGUSTICIFOLIA Nutt.
(Western Virginbower)

FAMILY: Ranunculaceae
LIFEFORM: Native woody vine 4-6 m tall (Harrington, 1964)
FRUIT: An achene with style 4-5 cm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 300,000-328,000--avg 315,000 (Rudolf, 1974b); 93,000-329,150 (Swingle, 1939); 93,000 (Mirov & Kraebel, 1937)

SEED MATURITY: Oct-Dec CO & UT (Rudolf, 1974b); Oct 10-Dec 30 UT (Plummer et al., 1968); Fall (Swingle, 1939); Jun-Sep CA (Mirov & Kraebel, 1937)
METHOD OF COLLECTION: Hand strip or vacuum harvest (Rudolf, 1974b; Plummer et al., 1968)
METHOD OF CLEANING: Hammervill and fan (Rudolf, 1974b; Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Dry (Swingle, 1939)
DURATION OF GOOD VIABILITY: 2 years (Rudolf, 1974b; Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 33-40°F for 60-180 days (Rudolf, 1974b); Moist chill at 3-5°C for 2-6 months (Heit, 1968)

LABORATORY GERMINATION

TEMPERATURE: Constant at 60-70°F (Milstein & Milstein, 1976); Alternating at 86°F day and 68°F night (Rudolf, 1974b)
GERMINATIVE CAPACITY: Complete in 20-30 days (Milstein & Milstein, 1976); 11-84% in 200 days (Rudolf, 1974b); 11-84% (Swingle, 1939); 21% in 27 days (Mirov & Kraebel, 1937)

CULTURAL PRACTICES

PLANTING TIME: Fall (Rudolf, 1974b); Spring (Swingle, 1939)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Rocky loam (Stark, 1966)
SOIL pH: 7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Shallow to deep (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist (Sutton & Johnson, 1974); along streams (Stark, 1966)
ORGANIC MATTER: Yes (Sutton & Johnson, 1974)
DRAINAGE: Well-drained (Sutton & Johnson, 1974)

COLEOGYNE RAMOSISSIMA Torr.
(Blackbrush)

FAMILY: Rosaceae
LIFEFORM: Native shrub up to 2 m tall (Harrington, 1964)
FRUIT: An achene 3 mm long with bent and twisted style (Harrington, 1964)

PRETREATMENT

STRATIFICATION AND SCARIFICATION: Moist chill at 4°C for 8 days (Bowns & West, 1976)

LABORATORY GERMINATION

TEMPERATURE: Constant at 4°C (Bowns & West, 1976)
LIGHT: Best in light but not essential (Bowns & West, 1976)
GERMINATIVE ENERGY: 80% in 6 days (Bowns & West, 1976)
GERMINATIVE CAPACITY: 90% in 13 days (Bowns & West, 1976)

CULTURAL PRACTICES

PLANTING TIME: Fall (Bowns & West, 1976)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Coarse (Stark, 1966)
SOIL DEPTH: Moderate (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
PRECIPITATION: 5+" (Stark, 1966)
FIELD PLANTING: Has been seeded successfully (Stark, 1966)

COLUTEA ARBORESCENS L.
(Common Bladder Senna)

FAMILY: Fabaceae
LIFEFORM: Introduced ornamental shrub (Bailey, 1949)
FRUIT: An inflated pod 2-3" long (Bailey, 1949)

PROCUREMENT

SEEDS/LB: 21,100 (Plummer et al., 1968); 25,000-270,454 (Swingle, 1939)
SEED MATURITY: Jul 25-Oct 5 UT (Plummer et al., 1968); Fall (Swingle, 1939)
METHOD OF COLLECTION: Hand pick the pods (Plummer et al., 1968)
METHOD OF CLEANING: Chopper-macerator, fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Dry (Swingle, 1939)
DURATION OF GOOD VIABILITY: 3 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Soak in sulfuric acid for 15 minutes (Swingle, 1939)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 10% (Swingle, 1939)

CORNUS STOLONIFERA Michx.
(Red-osier Dogwood)

FAMILY: Cornaceae
LIFEFORM: Native shrub to 4 m tall (Harrington, 1964)
FRUIT: A drupe 7-9 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 13,800-26,700--avg 18,500 (Brinkman, 1974c); 17,260 (Plummer et al., 1968); 17,300-21,824 (Swingle, 1939); 15,500 (McKeever, 1938)

SEED MATURITY: Jul-Oct MN (Brinkman, 1974c); Aug 20-Sep 10 UT (Plummer et al., 1968); Late summer-fall (Swingle, 1939)
METHOD OF COLLECTION: Strip or shake fruit from branches (Brinkman, 1974c); Hand pick into container (Plummer et al., 1968)
METHOD OF CLEANING: Macerate fruit in water or hammermill, dry (Brinkman, 1974c); Dybvig with water, dry (Plummer et al., 1968)

PRETREAMENT

METHOD OF STORAGE: Store dry in sealed containers at 38-41°F (Brinkman, 1974a; Swingle, 1939)
DURATION OF GOOD VIABILITY: 2-4 years (Brinkman, 1974c); 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 35-41°F for 60-90 days (Brinkman, 1974c); Moist chill at 41°F for 120 days (Babb, 1959); Moist chill at 35°F for 90 days, scarification reduces total germination (Peterson, 1953); Moist chill at 40-41°F for 113-290 days (Swingle, 1939); Soak in sulfuric adid for 1 hour then moist chill in peat (pH 3.95) at 5°C for 8 weeks (McKeever, 1938); Moist chill for 71-112 days (Nichols, 1934); Sow in soil over winter (Adams, 1927)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Brinkman, 1974c); Alternating at 80°F day and 45°F night (Peterson, 1953)
MOISTURE: Moist (Peterson, 1953)
GERMINATIVE ENERGY: 35% in 13-18 days (Brinkman, 1974c); 84% in 34 days (Peterson, 1953); 63% in 16 days (McKeever, 1938)
GERMINATIVE CAPACITY: 57% in 60-90 days (Brinkman, 1974c); 87% in 42 days (Peterson, 1953); 6-75% (Swingle, 1939); 71% in 33 days (McKeever, 1938); 25% in 21-277 days (Nichols, 1934); 73-76% (Adams, 1927)
COMMENTS: Dormancy due to both seed coat and immature embryo (McKeever, 1938)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-1/2" (Brinkman, 1974c)
PLANTING TIME: Fall (Brinkman, 1974c); Fall or spring with stratified seed (Peterson, 1953; Swingle, 1939)
EXPOSURE: Sun or shade (Stark, 1966)
SOIL TEXTURE: Medium to coarse (Sutton & Johnson, 1974)
SOIL pH: 7.0-8.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist to wet (Sutton & Johnson, 1974)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Good drainage, water for short period (Sutton & Johnson, 1974); Well-drained (Stark, 1966)
GREENHOUSE PLANTING: Reproduces well by cuttings (Swingle, 1939); Seedlings inhibited by treatment with growth substances (Barton, 1940)
NURSERY PLANTING: Mulch with 1/2-1" sawdust (Brinkman, 1974c)

COWANIA MEXICANA STANSBURIANA (Torr.) Jepson
(Mexican Cliffrose)

SYNONOMY: *Cowania mexicana, Cowania stansburiana*
FAMILY: Rosaceae
LIFEFORM: Native evergreen shrub to 3.5 m tall (Harrington, 1964)
FRUIT: An achene 3 mm long with a plumose style 25-50 mm long (Blauer et al., 1975)

PROCUREMENT

SEEDS/LB: 60,800-67,000 (Alexander et al., 1974); 64,615 (Plummer et al., 1968)
SEED MATURITY: Jul 15-Aug 30 (Alexander et al., 1974); Jul 5-Aug 10 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Hand pick or shake seed into containers (Alexander et al., 1974); Knock from bushes onto canvas or into hopper (Plummer et al., 1968)
METHOD OF CLEANING: Dry, hammermill, or Dybvig, and fan (Alexander et al., 1974); Chopper-macerator, fan, Dybvig, dry, and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Sealed containers at 36-41°F (Springfield, 1973a)
DURATION OF GOOD VIABILITY: 7 years (Alexander et al., 1974); 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill treatment may be helpful (Alexander et al., 1974); Moist chill at 3-5°C for 1 month (Heit, 1970)

LABORATORY GERMINATION

TEMPERATURE: Constant at 54-57°F (Springfield, 1973a); Alternating at 30°C day and 10°C night (Heit, 1970, 1968)
LIGHT: Does not require light (Heit, 1968)
GERMINATIVE CAPACITY: 89-99% in 90 days (Alexander et al., 1974); 95% (Springfield, 1973a); 90% in 10 days (Heit, 1970); 21% (Swingle, 1939)
COMMENTS: Staining embryos for 2 hours in an 0.5% TTC solution at 40°C gives nearly optimal results in terms of rapidity and intensity of staining (Piatt & Springfield, 1973)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-1/2" (Alexander et al., 1974)
PLANTING TIME: Fall or early winter (Alexander et al., 1974)
EXPOSURE: Sun (Sutton & Johnson, 1974); Seedlings survive only in shade (Woodmansee, 1969)
SOIL TEXTURE: Rocky to coarse (Sutton & Johnson, 1974)
SOIL pH: 7.0-8.0 (Stark, 1966)
SOIL DEPTH: Deep (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry (Stark, 1966)

DRAINAGE: Well-drained (Sutton & Johnson, 1974)

NURSERY PLANTING: Treatment of seed with rodenticide repellent is helpful (Alexander et al., 1974)

FIELD PLANTING: Drill 1/2-1 lb per 8-10 lb total seed, or broadcast 1-2 lb of seed per 12-20 lb of total seed (Alexander et al., 1974); Natural germination is erratic, dependent upon adequate moisture and proper timing of precipitation (Woodmansee, 1969)

CRATAEGUS CHRYSOCARPA Ashe
(Fireberry Hawthorn)

FAMILY: Rosaceae

LIFEFORM: Native small tree 2-7 m tall (Harrington, 1964)

FRUIT: A pome 8-9 mm long with 3-4 nutlets (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 10,750 (Brinkman, 1974d)

SEED MATURITY: Sep (Brinkman, 1974d)

METHOD OF COLLECTION: Hand pick (Brinkman, 1974d)

METHOD OF CLEANING: Macerate in water, dry (Brinkman, 1974d)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Brinkman, 1974d)

DURATION OF GOOD VIABILITY: 2-3 years (Brinkman, 1974d)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Brinkman, 1974d)

NURSERY PLANTING: Plant in rows 8-12" apart; do not keep in seedbed more than 1 year (Brinkman, 1974d)

CRATAEGUS SUCCULENTA Schrad.
(Fleshy Hawthorn)

FAMILY: Rosaceae

LIFEFORM: Native tall shrub or small tree up to 7 m tall (Harrington, 1964)

FRUIT: A pome 7-11 mm in diameter with 2-4 nutlets (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 20,600 (Brinkman, 1974d)

SEED MATURITY: Sep-Oct (Brinkman, 1974d)

METHOD OF COLLECTION: Hand pick (Brinkman, 1974d)

METHOD OF CLEANING: Macerate in water, dry (Brinkman, 1974d)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Brinkman, 1974d)

DURATION OF GOOD VIABILITY: 2-3 years (Brinkman, 1974d)

STRATIFICATOIN AND SCARIFICATION: Soak seeds 1/2 hour in sulfuric acid then moist chill at 40°F for 110-140 days (Brinkman, 1974d)

GERMINATIVE CAPACITY: 35-40% (Brinkman, 1974d)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Brinkman, 1974d)

NURSERY PLANTING: Plant in rows 8-12" apart; do not keep in seedbed more than 1 year (Brinkman, 1974d)

ELAEAGNUS ANGUSTIFOLIA L.
(Russian Olive)

FAMILY: Elaeagnaceae

LIFEFORM: Introduced shrub or tree to 7 m tall (Harrington, 1964)

FRUIT: An achene 1 cm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 2,900-5,160 (USDA Forest Service, 1976); 3,470-6,940--avg 5,160 (Olson, 1974a); 2,870 (Plummer et al., 1968); 1,846-4,828 (Swingle, 1939); 2,780 (McKeever, 1938)

SEED MATURITY: Aug-Oct (USDA Forest Service, 1976; Olson, 1974a); Aug 25-Jan 15 UT (Plummer et al., 1968); Fall (Swingle, 1939)

METHOD OF COLLECTION: Hand pick or strip onto canvas (USDA Forest Service, 1976; Olson, 1974a); Knock from trees onto canvas (Plummer et al., 1968)

METHOD OF CLEANING: Macerate with water and float or screen (Olson, 1974a); Dybvig with water and dry (Plummer et al., 1968)

PRETREATMENT

METHOD OF STROAGE: In sealed containers with 6-14% moisture at 33-40°F (USDA Forest Service, 1976); Dry in sealed containers at 34-50°F (Olson, 1974a); Dry (Swingle, 1939)

DURATION OF GOOD VIABILITY: Up to 3 years (USDA Forest Service, 1976; Olson, 1974a); 10 years (Plummer et al., 1968); 5 1/2 years (King, 1947)

STRATIFICATION AND SCARIFICATION: Soak seed for 1/2-1 hour in sulfuric acid then moist chill at 34-50°F for 60-90 days (USDA Forest Service, 1976; Olson, 1974a); Soak seed for 1/2-1 hour in sulfuric acid then moist chill at 3-5°C for 21-28 days (Heit, 1968); Moist chill at 40°F for 3 months (Stark, 1966); Moist chill at 34-50°F for 60-90 days (Hervey & Boyd, 1953; Swingle, 1939); After ripen in dry storage for

14 weeks then moist chill at 5°C for 14 weeks (King, 1947); Most chill at 5°C in peat (pH 3.95) for 6 weeks (McKeever, 1938)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Olson, 1974a); Constant at 20-30°C (Heit, 1968)
LIGHT: Best germination in light (Heit, 1968)
GERMINATIVE ENERGY: 7-76% in 10-32 days (Olson, 1974a); 44% in 18 days (King, 1947)
GERMINATIVE CAPACITY: 7-90% (USDA Forest Service, 1976); 7-79% in 60 days (Olson, 1974a; Swingle, 1939); 44% in 38 days (King, 1947); 86% in 11 days (McKeever, 1938)
COMMENTS: Dormancy due to both the seed coat and an immature embryo (McKeever, 1938)

CULTURAL PRACTICES

PLANTING DEPTH: Broadcast or drill 1/2" (USDA Forest Service, 1976); 1/2-1" (Olson, 1974a)
PLANTING TIME: Stratified seed in spring (Hartman & Kester, 1975); Late summer or fall (Olson, 1974a)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Variable (Stark, 1966)
SOIL pH: Will tolerate alkali (Stark, 1966)
SOIL SALINITY: Tolerates 10,000 ppm NaCl and $CaCl_2$ (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
DRAINAGE: Well-drained (Stark, 1966)
GREENHOUSE PLANTING: Reproduces well by cuttings (Swingle, 1939)
NURSERY PLANTING: Start in sand or peat; mulch fall sown seed (USDA Forest Service, 1976); Use cleaned seed to discourage rodents; mulch and avoid soil splash; seed 12-30 seeds per square foot (Olson, 1974a)

ELAEAGNUS COMMUTATA Bernh.
(Silverberry)

FAMILY: Elaeagnaceae
LIFEFORM: Native shrub or small tree 2-5 m tall (Harrington, 1964)
FRUIT: An achene (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 2,700-4,600--avg 3,800 (Olson, 1974a); 3,635-3,800 (Swingle, 1939)
SEED MATURITY: Aug-Sep (Olson, 1974a); Sep (Swingle, 1939)
METHOD OF COLLECTION: Hand pick or strip onto canvas (Olson, 1974a)
METHOD OF CLEANING: Macerate with water and float or screen (Olson, 1974a)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 34-50°F (Olson, 1974a)
DURATION OF GOOD VIABILITY: 1-2 years (Olson, 1974a)
STRATIFICATION AND SCARIFICATION: Moist chill at 34-50°F for 60-90 days (Olson, 1974a); Moist chill at 40°F for 90 days (Babb, 1959)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F (Olson, 1974a)
GERMINATIVE ENERGY: 52% in 13 days (Olson, 1974a)
GERMINATIVE CAPACITY: 90% (Hartman & Kester, 1975); 60% in 50 days (Olson, 1974a)
COMMENTS: There may be a germination inhibitor in the pit (Hartman & Kester, 1975)

CULTURAL PRACTICES

PLANTING DEPTH: 1/2-1" (Olson, 1974a)
PLANTING TIME: Late summer or fall (Olson, 1974a)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)
NURSERY PLANTING: Use cleaned seed to discourage rodents, mulch, avoid soil splash, plant 12-30 seeds per square foot (Olson, 1974a)

EPHEDRA TORREYANA Wats
(Torrey Ephedra)

FAMILY: Ephedraceae
LIFEFORM: Native shrub 25-100 cm tall (Harrington, 1964)
FRUIT: Nutlike (Stark, 1966)

CULTURAL PRACTICES

PLANTING TIME: Spring (Stark, 1966)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: On limestone and gypsum soils (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966; Harrington, 1964)

EPHEDRA VIRIDIS Coville
(Green Ephedra)

FAMILY: Ephedraceae
LIFEFORM: Native evergreen shrub 50-100 cm tall (Harrington, 1964)
FRUIT: Nutlike (Stark, 1966)

PROCUREMENT

SEEDS/LB: 25,200 (Kay et all, 1977e); 18,000 (Williams et al., 1974); 24,955 (Plummer et al., 1968)
SEED MATURITY: Jul 15-Sep 1 UT (Plummer et al., 1968)

METHOD OF COLLECTION: Knock seed from bush into hopper (Plummer et al., 1968)
METHOD OF CLEANING: Dry, fan, Crippen EP-26, fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store dry at 70°F (Young et al., 1977)
DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Germination may be increased by a period of after-ripening (Kay et al., 1977c)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 15-25°C day and 2-5 °C night (Young et al., 1977)
MOISTURE: Best at 0 bars tension; will germinate with tension as low as 8 bars (Young et al., 1977)
GERMINATIVE ENERGY: 58% in 12 days (Young et al., 1977)
GERMINATIVE CAPACITY: 77-87% in 30 days (Young et al., 1977); 56% in 5 days (Williams et al., 1974)

CULTURAL PRACTICES

PLANTING DEPTH: 1-2 cm (Kay et al., 1977e; Williams et al., 1974)
PLANTING TIME: Spring (Stark, 1966)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Medium to coarse, on limestone cliffs (Stark, 1966)
SOIL pH: Slight saline-alkaline tolerance (Stark, 1966)
SOIL DEPTH: Medium to shallow (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
PRECIPITATION: 6-10" (Stark, 1966)
FIELD PLANTING: Seeds well (Stark, 1966)

FALLUGIA PARADOXA (Don) Endl.
(Common Apacheplume)

FAMILY: Rosaceae
LIFEFORM: Native shrub 50-150 cm tall (Harrington, 1964)
FRUIT: An achene 3 mm long with plumose style 25-38 mm long (Blauer et al., 1975)

PROCUREMENT

SEEDS/LB: 420,000 (Blauer et al., 1975; Swingle, 1939; Mirov & Kraebel, 1937); 500,000-580,000--avg 54,000 (Deitschman et al., 1974c)
SEED MATURITY: Aug-Nov NV (Stark, 1966); Jun-Jul CA (Swingle, 1939; Mirov & Kraebel, 1937)
METHOD OF COLLECTION: Strip fruits or shake onto canvas (Deitschman et al., 1974c)

PRETREATMENT

METHOD OF STORAGE: Store dry seed in cloth or burlap bag in ventilated warehouse (Deitschman et al., 1974c; Swingle, 1939)
DURATION OF GOOD VIABILITY: 2-3 years (Deitschman et al., 1974c)
STRATIFICATION AND SCARIFICATION: Moist chill treatments may be beneficial (Swingle, 1939)

LABORATORY GERMINATION

TEMPERATURE: Constant at 32-38°F (Deitschman et al., 1974c)
GERMINATIVE ENERGY: 42% in 14 days (Deitschman et al., 1974c); 42% in 7 days (Mirov & Kraebel, 1937)
GERMINATIVE CAPACITY: 60-73% in 60 days (Deitschman et al., 1974c); 42-62% (Swingle, 1939)

CULTURAL PRACTICES

PLANTING TIME: Fall or spring (Deitschman et al., 1974c); Spring (Swingle, 1939)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Rocky, sandy, and limestone washes (Stark, 1966)
SOIL DEPTH: Moderate to deep (Blauer et al., 1975)
SOIL MOISTURE: Dry (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)
NURSERY PLANTING: Broadcast seed and cover with 1/16" soil and 1/8-1/4" sand on firm seedbed (Deitschman et al., 1974c)
FIELD PLANTING: Has considerable ecotypic variation (Mirov & Kraebel, 1937)

FORESTIERA NEOMEXICANA Gray
(Desert Olive)

FAMILY: Oleaceae
LIFEFORM: Native shrub 1-3.5 m tall (Harrington, 1964)
FRUIT: A drupe 6-8 mm long (Harrington, 1964)

PROCUREMENT

SEED MATURITY: Summer (Swingle, 1939)

PRETREATMENT

METHOD OF STORAGE: Dry (Swingle, 1939)
STRATIFICATION AND SCARIFICATION: Moist chill for 30 days (Swingle, 1939)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 55-72% (Swingle, 1939)

CULUTRAL PRACTICES

PLANTING TIME: Fall or spring with stratified seed (Swingle, 1939)
EXPOSURE: Sun or partial shade (Stark, 1966)
SOIL TEXTURE: Medium to fine (Stark, 1966)

SOIL DEPTH: Moderate (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)

FRAXINUS ANOMALA Torr. ex S. Wats
(Singleleaf Ash)

FAMILY: Oleaceae
LIFEFORM: Native shrub or small tree 2-8 m tall (Harrington, 1964)
FRUIT: A samara 12-25 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 20,350 (Plummer et al., 1968); 22,050 (Swingle, 1939)
SEED MATURITY: Jul 15-Sep 10 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Hand strip into container (Plummer et al., 1968)
METHOD OF CLEANING: Hammermill and fan (Plummer et al., 1968)

PRETREATMENT

DURATION OF GOOD VIABILITY: 2-3 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 4°C for 2-4 months (Hartmann & Kester, 1975)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 0% (Hartmann & Kester, 1975)

CULTURAL PRACTICES

EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Prefers limestone (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)

GRAYIA BRANDEGEI A. Gray
(Spineless Hopsage)

FAMILY: Chenopodiaceae
LIFEFORM: Native shrub 20-70 cm (Harrington, 1964)
FRUIT: A 1-seeded utricle with bracts 5-6 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 190,000 (Smith, 1974a); 189,950 (Plummer et al., 1968)
SEED MATURITY: Jun-Jul (Smith, 1974a); Sep 11-Dec 15 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Strip seeds into container (Smith, 1974a)
METHOD OF CLEANING: Hammermill and fan (Smith, 1974a); Pick out sticks and stems (Plummer et al., 1968)

PRETREATMENT

DURATION OF GOOD VIABILITY: 2 years (Plummer et al., 1968)

CULTURAL PRACTICES

SOIL TEXTURE: Fine to medium (Blauer et al., 1976)
SOIL pH: 7.4-7.7 (Blauer et al., 1976); tolerates alkali (Smith, 1974a)

GRAYIA SPINOSA (Hook.) Moq.
(Spiny Hopsage)

FAMILY: Chenopodiaceae
LIFEFORM: Native shrub 30-100 cm tall (Harrington, 1964)
FRUIT: A utricle with winged bracts 5-12 mm long (Wood et al., 1976)

PROCUREMENT

SEEDS/LB: Fruits are 153,600-168,000, seeds are 395,200-424,000 (Smith, 1974a); 166,765 (Plummer et al., 1968); 395,200 (Glazebrook, 1941); 153,600 (Swingle, 1939)
SEED MATURITY: Jun-Jul (Smith, 1974a); Jul 1-Aug 10 UT (Plummer et al., 1968); Jul-Aug NV (Stark, 1966); Summer (Swingle, 1939)
METHOD OF COLLECTION: Strip seeds into container (Smith, 1974a); Knock seed from bushes into hopper or onto canvas (Plummer et al., 1968)
METHOD OF CLEANING: Hammermill and fan (Smith, 1974a); Pick out sticks and stems and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store in a cool, dry place (Smith, 1974a)
DURATION OF GOOD VIABILITY: 6 years (Smith, 1974a; King, 1947); 2 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 38°F for 60-90 days (Smith, 1974a); Stratification requirement decreases with the age of seed, 6-years-old (2 weeks) and 4-years-old (2-12 weeks) (King, 1947)

LABORATORY GERMINATION

TEMPERATURE: Constant at 10-15°C or alternating at 10-30°C day and 5°C night (Wood et al., 1976); Alternating at 86°F day and 68°F night (Smith, 1974a); Alternating at 30°C day and 20°C night (Glazebrook, 1941)
MOISTURE: Best at 0 bars tension, will germinate with as low as 12-16 bars tension (Wood et al., 1976)
LIGHT: Neither light nor dark sensitive (Glazebrook, 1941)
GERMINATIVE ENERGY: 85-90% in 14 days (Wood et al., 1976); 6% (Housley, 1952); 25% in 10 days (King, 1947)

GERMINATIVE CAPACITY: 88% in 35 days (Smith, 1974a); Complete in 55 days (Housley, 1952); 51% (King, 1947); 92% in 35 days (Glazebrook, 1941)

CULTURAL PRACTICES

PLANTING DEPTH: 1 cm (Kay et al., 1977d); 0.5 cm (Wood et al., 1976); On surface (Glazebrook, 1941)
PLANTING TIME: Mar (Stark, 1966); Early fall or late spring (Glazebrook, 1941)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Variable (Stark, 1966)
SOIL pH: Tolerates alkali (Smith, 1974a); High alkali tolerance, slight saline-alkali tolerance (Stark, 1966)
SOIL DEPTH: 36-60" (Stark, 1966)
PRECIPITATION: 6-14+" (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)

GUTIERREZIA SAROTHRAE (Pursh) Britt. & Rusby
(Broom Snakewood)

FAMILY: Asteraceae
LIFEFORM: Native half shrub 10-70 cm tall (Harrington, 1964)
FRUIT: An achene (Harrington, 1964)

LABORATORY GERMINATION

TEMPERATURE: Constant at 60-70°F (Kruse, 1970)
MOISTURE: Moist, will germinate with a tension as low as 6 atmospheres (Kruse, 1970)
GERMINATIVE CAPACITY: 95% (Kruse, 1970)

CULTURAL PRACTICES

PLANTING TIME: Spring (Stark, 1966)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Medium to coarse (Stark, 1966)
SOIL SALINITY: Moderate salt tolerance (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
PRECIPITATION: 3-5" (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)

HOLODISCUS DUMOSUS (Nutt.) Heller
(Rock Spiraea)

FAMILY: Rosaceae
LIFEFORM: Native shrub 50-300 cm tall (Harrington, 1964)
FRUIT: An achene (Harrington, 1964)

PRETREATMENT

STRATIFICATION AND SCARIFICATION: Moist chill at 5°C for 18 weeks (King, 1947)

LABORATORY GERMINATION

MOISTURE: Near saturation (King, 1947)
COMMENTS: Sound seed can be determined by observing embryos wet with a 15x scope with black light (King, 1947)

CULTURAL PRACTICES

PLANTING TIME: Fall (Stark, 1966)
SOIL TEXTURE: Medium to coarse (Stark, 1966)
SOIL pH: Found on limestone cliffs (Stark, 1966)
SOIL DEPTH: Shallow (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)
NURSERY PLANTING: Easily grown from seed (Stark, 1966)

JUNIPERUS COMMUNIS L.
(Common Juniper)

FAMILY: Cupressaceae
LIFEFORM: Native shrub to 100 cm tall (Harrington, 1964)
FRUIT: Berry-like, 1-4 seeded (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 25,450-54,500--avg 36,500 (Johnson & Alexander, 1974); 24,454-32,500 (Swingle, 1939)
SEED MATURITY: Aug-Oct (Johnson & Alexander, 1974); Fall (Swingle, 1939)
METHOD OF COLLECTION: Strip or pick into container or shake onto canvas (Johnson & Alexander, 1974)
METHOD OF CLEANING: Fan, Dybvig with water, dry and fan (Johnson & Alexander, 1974)

PRETREATMENT

STRATIFICATION AND SCARIFICATION: Warm stratify at 86°F day and 68°F night for 45-90 days then moist chill to induce germination for 90+ days (Johnson & Alexander, 1974)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Johnson et al., 1974)
GERMINATIVE CAPACITY: 7-75% in 20-30 days (Johnson & Alexander, 1974)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Johnson et al., 1974)
PLANTING TIME: Late summer of fall (Johnson & Alexander, 1974); Spring (Stark, 1966)
EXPOSURE: Sun or shade (Sutton & Johnson, 1974)
SOIL TEXTURE: Fine to coarse (Stark, 1966)
SOIL pH: 7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Deep (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry to moist (Sutton & Johnson, 1974)
ORGANIC MATTER: If possible (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
GREENHOUSE PLANTING: Reproduces well by cuttings (Swingle, 1939)
NURSERY PLANTING: Mulch, have moist seedbed, remove mulch on germination, give light shade (Johnson & Alexander, 1974)

KOCHIA AMERICANA S. Wats
(Desert Molly)

FAMILY: Chenopodiaceae
LIFEFORM: Native half shrub 10-40 cm tall (Harrington, 1964)
FRUIT: 1-seeded utricle with wings 1.5-2 mm long (Harrington, 1964)

PRETREATMENT

METHOD OF STORAGE: Store dry at 70°F (Clarke & West, 1969)
STRATIFICATION AND SCARIFICATION: Mechanical scarification promotes germination (Clarke & West, 1969)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Clarke & West, 1969)
COMMENTS: Salinity tolerance during germination is very high up to 10% NaCl solution but tolerance may vary with seed source (Clarke & West, 1969)

CULTURAL PRACTICES

SOIL pH: Saline-alkaline tolerant (Clarke & West, 1969)

LEPTODACTYLON PUNGENS (Torr.) Rydb.
(Prickly Phlox)

FAMILY: Polemoniaceae
LIFEFORM: Native half shrub 10-20 cm tall (Harrington, 1964)
FRUIT: A capsule (Stark, 1966)

CULTURAL PRACTICES

EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Medium to coarse (Stark, 1966)
SOIL pH: Found on limestone (Stark, 1966)
SOIL DEPTH: Moderate (Stark, 1966)

LONICERA INVOLUCRATA (Rich.) Banks
(Black Twinberry)

FAMILY: Caprifoliaceae
LIFEFORM: Native shrub 50-300 cm tall (Harrington, 1964)
FRUIT: Berry-like and few seeded 8 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 227,000-477,000--avg 326,500 (Brinkman, 1974e); 226,800-476,800 (Swingle, 1939)
SEED MATURITY: Jul-Aug Northern Rockies (Brinkman, 1974e); Late summer to fall UT (Sutton & Johnson, 1974); Aug-Sep NV (Stark, 1966); Early summer (Swingle, 1939)
METHOD OF COLLECTION: Hand pick or strip into container (Brinkman, 1974e)
METHOD OF CLEANING: Macerate in water, dry (Brinkman, 1974e)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 34-38°F (Brinkman, 1974e)
STRATIFICATION AND SCARIFICATION: Moist chill (Brinkman, 1974e)

LABORATORY GERMINATION

TEMPERATURE: Constant at 18°C (Heit, 1968)
GERMINATIVE CAPACITY: 83% (Brinkman, 1974e; Swingle, 1939)

CULTURAL PRACTICES

PLANTING DEPTH: 1/8-1/4" (Brinkman, 1974e)
PLANTING TIME: Fall (Brinkman, 1974e)
EXPOSURE: Shade (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium (Sutton & Johnson, 1974)
SOIL pH: 7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate to shallow (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist (Stark, 1966)
ORGANIC MATTER: If possible (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Mulch with 2-3" straw (Brinkman, 1974e)

LYCIUM HALIMIFOLIUM Mill.
(Matrimony Vine)

SYNONOMY: *Lycium barbarum*
FAMILY: Solanaceae
LIFEFORM: Introduced shrub 1-6 m tall (Harrington, 1964)
FRUIT: Fleshy berry 1 cm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 266,100 (Glazebrook, 1941); 260,000 (Swingle, 1939)
SEED MATURITY: Fall (Swingle, 1939)

PRETREATMENT

METHOD OF STORAGE: Dry (Swingle, 1939)
STRATIFICATION AND SCARIFICATION: Moist chill at 5°C for 2-4 weeks (Glazebrook, 1941)

LABORATORY GERMINATION

GERMINATIVE ENERGY: 63% in 10 days (Glazebrook, 1941)
GERMINATIVE CAPACITY: 71-73% in 20-30 days (Glazebrook, 1941)

CULTURAL PRACTICES

PLANTING TIME: Spring (Swingle, 1939)
GREENHOUSE PLANTING: Reproduces well by cuttings (Swingle, 1939)

MAHONIA FREMONTII (Torr.) Fedde
(Fremont Barberry)

SYNONOMY: *Berberis fremontii*
FAMILY: Berberidaceae
LIFEFORM: Native shrub 1-3 m tall (Harrington, 1964)
FRUIT: A berry 6-14 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 42,000 (Rudolf, 1974a); 41,770 (Plummer et al., 1968)
SEED MATURITY: Jul-Aug UT (Rudolf, 1974a); Jul 15-Aug 20 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Hand pick or flail into receptacles or cloth on the ground (Rudolf, 1974a); Hand strip into hoppers (Plummer et al., 1968)
METHOD OF CLEANING: Macerate with water then screen or float, dry (Rudolf, 1974a); Dybvig with water, dry and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Sealed containers slightly above freezing (Rudolf, 1974a)
DURATION OF GOOD VIABILITY: 5 years (Rudolf, 1974a; Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 40°F for 2-6 weeks (Stark, 1966); None necessary (Swingle, 1939)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 85% (Rudolf, 1974a); 81% (Swingle, 1939)

CULTURAL PRACTICES

PLANTING TIME: Fall (Rudolf, 1974a)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Rocky (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)
NURSERY PLANTING: Cover seed with 1/8-1/2" soil and 1/4" sand (Rudolf, 1974a)
FIELD PLANTING: Mulch improves germination, mold may attack seeds planted with berries, under natural conditions seeds germinate the spring following dispersal (Rudolf, 1974a)

MAHONIA REPENS (Lindl.) G. Don
(Creeping Barberry)

SYNONOMY: *Berberis repens*
FAMILY: Berberidaceae
LIFEFORM: Native shrub less than 25 cm tall (Harrington, 1964)
FRUIT: A berry 7-8 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 54,000-71,000--avg 62,000 (Rudolf, 1974a); 71,120 (Plummer et al., 1968)
SEED MATURITY: Jun-Sep SD (Rudolf, 1974a); Aug 5-Sep 10 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Hand pick or flail onto receptacles or cloth on the ground (Rudolf, 1974a); Hand strip into hoppers (Plummer et al., 1968)
METHOD OF CLEANING: Macerate with water then screen or float, dry (Rudolf, 1974a); Dybvig with water, dry and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Sealed containers slightly above freezing (Rudolf, 1974a)
DURATION OF GOOD VIABILITY: 5 years (Rudolf, 1974a; Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Successive cold, warm, and cold stratification periods aid germination (Rudolf, 1974a); Moist chill at 2°C for 16 weeks in an 0.001 molar solution of gibberellic acid (McDonough, 1969); Moist chill at 1°C for 30 days then warm at 20°C for 60 days then moist chill at 1°C for 196 days, scarification not necessary (McLean, 1967)

LABORATORY GERMINATION

TEMPERATURE: Constant at 34°F or 70°F (Rudolf, 1974a); Constant at 2°C (McDonough, 1969)
MOISTURE: Wet (Rudolf, 1974a)
GERMINATIVE ENERGY: 62% in 150 days at 34°F (Rudolf, 1974a)
GERMINATIVE CAPACITY: 74% in 196 days at 34°F or 10 days at 70°F (Rudolf, 1974a); 79% in 28 days (McDonough, 1969); 74% (McLean, 1967)

CULTURAL PRACTICES

PLANTING TIME: Fall (Rudolf, 1974a)
EXPOSURE: Sun, partial shade, or shade (Sutton & Johnson, 1974)
SOIL TEXTURE: Coarse to medium, loam (Stark, 1966)
SOIL pH: 5.5-7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Shallow to moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry to moist (Sutton & Johnso 1974)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Cover with 1/8-1/2" soil and 1/4" sand (Rudolf, 1974a)

FIELD PLANTING: Mulch improves germination, mold may attack seed planted with berries, under natural conditions seeds germinate the spring following dispersal (Rudolf, 1974a)

MENODORA SCABRA A. Gray
(Rough Menodora)

FAMILY: Oleaceae
LIFEFORM: Native half shrub 7-35 cm tall (Harrington, 1964)
FRUIT: A capsule 5-7 mm long and 7-12 mm wide (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 102,000-112,000 (Krugman, 1974); 102,500 (Swingle, 1939)
SEED MATURITY: Sep-Nov (Krugman, 1974); Early summer (Swingle, 1939)

PRETREATMENT

METHOD OF STORAGE: Store dry at 70°F (Krugman, 1974; Swingle, 1939)
STRATIFICATION AND SCARIFICATION: Does not need stratification (Stark, 1966; Swingle, 1939)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 70-99% (Krugman, 1974; Swingle, 1939)
COMMENTS: Seeds germinate freely (Stark, 1966)

CULTURAL PRACTICES

PLANTING TIME: Spring (Stark, 1966); Spring or summer (Swingle, 1939)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Medium to coarse (Stark, 1966)
SOIL DEPTH: Moderate to shallow (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)

OPUNTIA FRAGILIS (Nutt.) Haw.
(Brittle Pricklypear Cactus)

FAMILY: Cactaceae
LIFEFORM: Native succulent shrub, joints 1.5-4 cm long (Harrington, 1964)
FRUIT: Berry-like, dry and spiny, seed 5-7 mm long (Harrington, 1964)

CULTURAL PRACTICES

PLANTING TIME: Summer (Stark, 1966)
EXPOSURE: Shade or semi-shade (Stark, 1966)
SOIL TEXTURE: Medium to fine (Stark, 1966)
SOIL DEPTH: Moderate to deep (Stark, 1966)
SOIL MOISTURE: Dry (Harrington, 1964)

PARTHENOCISSUS INSERTA (Kern.) K. Fritsch.
(Thicket Creeper)

FAMILY: Vitaceae
LIFEFORM: Native woody vine (Harrington, 1964)
FRUIT: A berry 5-7 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 14,100-23,300--avg 18,800 (Gill & Pogge, 1974a)
SEED MATURITY: Jul-Aug (Gill & Pogge, 1974a)
METHOD OF COLLECTION: Hand strip into container (Gill & Pogge, 1974a)
METHOD OF CLEANING: Fan, hammermill with water, and dry (Gill & Pogge, 1974a)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 41°F (Gill & Pogge, 1974a)
DURATION OF GOOD VIABILITY: 2 years (Gill & Pogge, 1974a)
STRATIFICATION AND SCARIFICATION: Moist chill at 41°F for 60 days (Gill & Pogge, 1974a); Moist chill at 40°F for 2 months (Stark, 1966)

LABORATORY GERMINATION

GERMINATIVE ENERGY: Most intensive germination in 15 days (Gill & Pogge, 1974a)
GERMINATIVE CAPACITY: 70-80% in 30 days (Gill & Pogge, 1974a)

CULTURAL PRACTICES

PLANTING DEPTH: 3/8" (Gill & Pogge, 1974a)
PLANTING TIME: Fall or with stratified seed in spring (Gill & Pogge, 1974a); Spring (Stark, 1966)
EXPOSURE: Sun or shade (Stark, 1966)
SOIL TEXTURE: Variable (Stark, 1966)
SOIL MOISTURE: Moist (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)
NURSERY PLANTING: 10 plants per square foot (Gill & Pogge, 1974a)

PARTHENOCISSUS VITACEA (Knerr) Hitchc.
(Virginia Creeper)

SYNONOMY: *Parthenocissus quinquefolia*
FAMILY: Vitaceae
LIFEFORM: Native woody vine (Harrington, 1964)
FRUIT: A berry 5-7 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 12,000-19,900 (Swingle, 1939)
SEED MATURITY: Sep-Oct, fall (Adams, 1927)

PRETREATMENT

METHOD OF STORAGE: Dry (Swingle, 1939)
STRATIFICATION AND SCARIFICATION: Benefits from a moist chill treatment (Swingle, 1939); Sow in soil outdoors over winter (Adams, 1927)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 99% (Swingle, 1939); 41-45% in 242-595 days (Adams, 1927)

CULTURAL PRACTICES

PLANTING TIME: Fall or spring (Swingle, 1939); Fall (Adams, 1927)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)

PERAPHYLLUM RAMOSISSIMUM Nutt. (Squawapple)

FAMILY: Rosaceae
LIFEFORM: Native shrub to 2 m tall (Harrington, 1964)
FRUIT: A fleshy pome 10-15 mm in diameter with 4 seeds (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 25,900-44,600 (Smith, 1974b); 23,750 (Plummer et al., 1968)
SEED MATURITY: Late Jun-Jul (Smith, 1974b); Jul 5-Aug 20 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Hand pick into containers (Smith, 1974b); Strip or knock fruit into hopper or onto canvas (Plummer et al., 1968)
METHOD OF CLEANING: Mash fruit in water, dry and fan (Smith, 1974b); Dybvig with water, dry and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store dry in cool ventilated metal container (Smith, 1974b)
DURATION OF GOOD VIABILITY: 5 years (Smith, 1974b; Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill in plastic bags at 38°F for 45 days (Smith, 1974b)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 87°F day and 68°F night (Smith, 1974b)
GERMINATIVE ENERGY: 96% in 180 days (Monsen & Christensen, 1975)
GERMINATIVE CAPACITY: 96% in 180 days (Monsen & Christensen, 1975); 9-51% in 30-90+ days (Smith, 1974b)

CULTURAL PRACTICES

PLANTING TIME: Fall (Monsen & Christensen, 1975)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Medium (Stark, 1966)
SOIL pH: Near acid soils (Stark, 1966)
SOIL DEPTH: 10-60+" (Stark, 1966)
SOIL MOISTURE: Dry (Smith, 1974b); Dry to moist (Stark, 1966)
PRECIPITATION: 8-14" (Stark, 1966)
DRAINAGE: Well drained (Smith, 1966)
NURSERY PLANTING: Rarely does well in cultivation (Stark, 1966)

PHILADELPHUS MICROPHYLLUS Gray (Littleleaf Mockorange)

FAMILY: Hydrangeaceae
LIFEFORM: Native shrub 80-200 cm tall (Harrington, 1964)
FRUIT: A capsule, seeds numerous (Harrington, 1964)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 69% (Swingle, 1939)

PHYSOCARPUS ALTERNANS (Jones) J. T. Howell (Dwarf Ninebark)

FAMILY: Rosaceae
LIFEFORM: Native shrub up to 1 m tall (Harrington, 1964)
FRUIT: A capsule (Harrington, 1964)

CULTURAL PRACTICES

PLANTING TIME: Spring (Stark, 1966)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Coarse (Stark, 1966)
SOIL DEPTH: Shallow (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)

PHYSOCARPUS MALVACEUS (Greene) Kuntze (Mallow Ninebark)

FAMILY: Rosaceae
LIFEFORM: Native shrub 0.5-2 m tall (Hitchcock & Cronquist, 1973)
FRUIT: A capsule with 2-4 seeds (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 756,000 (Gill & Pogge, 1974b)
SEED MATURITY: Aug ID, Aug 20-Sep 25 MT (Gill & Pogge, 1974b); Fall, winter UT (Sutton & Johnson, 1974)
METHOD OF COLLECTION: Hand pick or strip onto drop cloth (Gill & Pogge, 1974b)
METHOD OF CLEANING: Dry, thresh and clean (Gill & Pogge, 1974b)

PRETREATMENT

METHOD OF STORAGE: Store dry at room temperature (Gill & Pogge, 1974b)
STRATIFICATION AND SCARIFICATION: Moist chill at 40-43°F for 77 days (Gill & Pogge, 1974b)

LABORATORY GERMINATION

TEMPERATURE: Constant at 80°F (Gill & Pogge, 1974b)
GERMINATIVE ENERGY: 14% in 3 days (Gill & Pogge, 1974b)
GERMINATIVE CAPACITY: 17% in 30 days (Gill & Pogge, 1974b)
COMMENTS: Germinative capacity low due to large percentage of unsound seed (Gill & Pogge, 1974b)

PHYSOCARPUS OPULIFOLIUS (L.) Maxim
(Common Ninebark)

FAMILY: Rosaceae
LIFEFORM: Native shrub 3-10 ft tall (Vines, 1960)
FRUIT: A follicle 1/4-1/2" in length 2-4 seeded (Vines, 1960)

PROCUREMENT

SEEDS/LB: 454,000-1,666,000--avg 1,045,000 (Gill & Pogge, 1974b); 73,000-1,661,000 (Swingle, 1939)
SEED MATURITY: Aug-Oct WV (Gill & Pogge, 1974b); Sep-Oct AK (Vines, 1960); Fall (Swingle, 1939)
METHOD OF COLLECTION: Hand pick or strip onto drop cloth (Gill & Pogge, 1974b)
METHOD OF CLEANING: Dry, thresh and clean (Gill & Pogge, 1974b)

PRETREATMENT

METHOD OF STORAGE: Store dry at room temperature (Gill & Pogge, 1974b; Swingle, 1939)
STRATIFICATION AND SCARIFICATION: May benefit from moist chill treatment (Swingle, 1939)

LABORATORY GERMINATION

COMMENTS: Germination capacity low due to large percentage of unsound seed (Gill & Pogge, 1974b)

CULTURAL PRACTICES

PLANTING TIME: Fall (Gill & Pogge, 1974b); Fall or spring (Swingle, 1939)
EXPOSURE: Sun or thin shade (Gill & Pogge, 1974b)
SOIL TEXTURE: Sandy or rocky soils (Vines, 1960)
SOIL pH: 7.0 (Gill & Pogge, 1974b)
GREENHOUSE PLANTING: Reproduces well from hardwood cuttings (Vines, 1960; Swingle, 1939)
NURSERY PLANTING: Mulch (Gill & Pogge, 1974b; Swingle, 1939); Should get 30,000 plants from 1 lb of seed (Gill & Pogge, 1974b)

POTENTILLA FRUTICOSA L.
(Shrubby Cinquefoil)

FAMILY: Rosaceae
LIFEFORM: Native shrub 30-100 cm tall (Harrington, 1964)
FRUIT: Densely hairy achene 2 mm long (Harrington, 1964)

CULTURAL PRACTICES

EXPOSURE: Semi-shade (Stark, 1966)
SOIL TEXTURE: Medium (Stark, 1966)
SOIL DEPTH: Deep (Stark, 1966)
SOIL MOISTURE: Moist (Stark, 1966)
SOIL DRAINAGE: Well drained (Stark, 1966)
FIELD PLANTING: May be difficult to establish from seed (Stark, 1966)

PRUNUS AMERICANA Marsh
(American Plum)

FAMILY: Rosaceae
LIFEFORM: Native tall shrub or small tree to 5 m tall (Harrington, 1964)
FRUIT: A one-seeded drupe 1.5-2.5 cm long with a stone 20-30 mm in diameter (Grisez, 1974; Harrington, 1964)

PROCUREMENT

SEEDS/LB: 550-1,500--avg 870 (Grisez, 1974); 810 (Plummer et al., 1968); 600-1,300 (Swingle, 1939)
SEED MATURITY: Jun-Oct (Grisez, 1974); Sep 5-Oct 5 UT (Plummer et al., 1968); Summer to late summer (Swingle, 1939)
METHOD OF COLLECTION: Hand pick or strip into container or onto canvas (Grisez, 1974); Knock from plants or strip into container (Plummer et al., 1968)
METHOD OF CLEANING: Hammermill at low speed in water and screen (Grisez, 1974); Dybvig with water and dry (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store in just below surface dry conditions at 34°F (Grisez, 1974; Plummer et al., 1968); In a moist room at 7-10°C (Giersbach & Crocker, 1932)
DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968); 4 1/2 years (Giersbach & Crocker, 1932)
STRATIFICATION AND SCARIFICATION: Moist chill at 36-41°F for 90-150 days (Griesez, 1974; Roe, 1941); Moist chill at 41°F for 150 days (Babb, 1959); Moist chill at 41°F for 150-180 days (Swingle, 1939); Moist chill at 5°C for 5 months (Giersbach & Crocker, 1932)

LABORATORY GERMINATION

TEMPERATURE: Constant at 50°F (Grisez, 1974; Roe, 1941); Constant at 5°C (Giersbach & Crocker, 1932)
GERMINATIVE ENERGY: 67% in 33 days (Roe, 1941)
GERMINATIVE CAPACITY: 60% in 60 days (Grisez, 1974); 86% in 60 days (Roe, 1941); 43% (Swingle, 1939); 52-71% in 150-180 days (Giersbach & Crocker, 1932)
COMMENTS: Seed from northern Minnesota germinates better at 50°F while seed from Nebraska did better at 80°F day and 70°F night [Grisez, 1974)

CULTURAL PRACTICES

PLANTING DEPTH: 1-2" (Grisez, 1974)
PLANTING TIME: Fall or spring with stratified seed (Grisez, 1974; Swingle, 1939); Spring (Stark, 1966); Spring with stratified seed (Giersbach & Crocker, 1932)
EXPOSURE: Sun (Sutton & Johnson, 1974); Sun or shade (Stark, 1966)
SOIL TEXTURE: Medium (Sutton & Johnson, 1974)
SOIL pH: 7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry to moist (Stark, 1966)
ORGANIC MATTER: Yes (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Stark, 1966)
GREENHOUSE PLANTING: Reproduces well by cuttings (Swingle, 1939)
NURSERY PLANTING: Rodents must be kept out of nursery, sow 4 seeds per square foot (Grisez, 1974); Sow seeds in cold frame in late November and mulch the seedbed (Giersbach & Crocker, 1932)

PRUNUS BESSEYI Bailey
(Bessey Cherry)

FAMILY: Rosaceae
LIFEFORM: Native shrub to 1.5 m tall (Harrington, 1964)
FRUIT: A one-seeded drupe 12-18 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 1,500-4,000--avg 2,400 (Grisez, 1974); 2,965 (Plummer et al., 1968); 1,500-2,264 (Swingle)
SEED MATURITY: Jul-Sep NB (Grisez, 1974); Aug 1-Sep 15 UT (Plummer et al., 1968); Summer (Swingle, 1939)
METHOD OF COLLECTION: Hand pick or strip into container or onto canvas (Grisez, 1974); Beat bushes with a canvas underneath (Plummer et al., 1968)
METHOD OF CLEANING: Dybvig with water and dry (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store at just below surface dry condition in sealed containers at 34°F (Grisez, 1974; Swingle, 1939)
DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 36-41°F for 120 days (Grisez, 1974); Moist chill at 41°F for 100 days (Babb, 1959); Sow in soil out of doors over winter (Adams, 1927)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 72% in 60 days (Grisez, 1974); 72% (Swingle, 1939); 80% in 685 days (Adams, 1927)

CULTURAL PRACTICES

PLANTING TIME: Fall or with stratified seed in spring (Grisez, 1974; Swingle, 1939); Spring (Stark, 1966)
EXPOSURE: Sun (Stark, 1966)
SOIL MOISTURE: Moderately moist (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)
GREENHOUSE PLANTING: Reproduces well by cuttings (Swingle, 1939)
NURSERY PLANTING: Rodents must be kept out of nursery, plant 6-7 seeds per square foot (Grisez, 1974)

PRUNUS PENSYLVANICA L. F.
(Pincherry)

FAMILY: Rosaceae
LIFEFORM: Native shrub or small tree to 5 m tall (Harrington, 1964)
FRUIT: A one-seeded drupe 6-7 mm wide (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 8,000-21,800--avg 14,200 (Grisez, 1974); 21,760 (Swingle, 1939)
SEED MATURITY: Late Jul-Early Aug PA (Grisez, 1974); Summer (Swingle, 1939)
METHOD OF COLLECTION: Hand pick or strip into container or onto canvas (Grisez, 1974)
METHOD OF CLEANING: Hammermill at low speed in water and screen (Grisez, 1974)

PRETREATMENT

METHOD OF STORAGE: Store at just below dry surface condition in sealed containers at 34°F (Grisez, 1974); Dry storage at room temperature shortens afterripening period (Hargrave, 1937)
STRATIFICATION AND SCARIFICATION: Warm stratify at 68°F for 60 days them moist chill at 36-41°F for 120 days (Grisez, 1974); Warm stratify at 77°F for 60 days then moist chill at 41°F for 90 days (Babb, 1959)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 77°F day and 50°F night (Grisez, 1974)
GERMINATIVE CAPACITY: 62% in 60 days (Grisez, 1974); 34% in 270 days (Hargrave, 1937)

CULTURAL PRACTICES

PLANTING TIME: Fall or stratified seed in spring (Grisez, 1974; Swingle, 1939)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)
FIELD PLANTING: Rodents must be kept out of nursery (Grisez, 1974)

PRUNUS VIRGINIANA L.
(Common Chokecherry)

FAMILY: Rosaceae
LIFEFORM: Native shrub or small tree to 10 m tall (Harrington, 1964)
FRUIT: A one-seeded drupe 3-6 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 3,010-8,400--avg 4,790 (Grisez, 1974); 4,150 (Plummer et al., 1968); 3,320-8,400 (Swingle, 1939)
SEED MATURITY: Early Aug PA, Aug-Sep CA, Jul-Oct eastern U.S. (Grisez, 1974); Jul 25-Sep 15 UT (Plummer et al., 1968); Summer (Swingle, 1939)
METHOD OF COLLECTION: Hand pick or strip into container or onto canvas (Grisez, 1974); Beat bushes with a canvas underneath (Plummer et al., 1968)
METHOD OF CLEANING: Dybvig with water and dry (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store at just below surface dry condition in sealed containers at 34°F (Grisez, 1974)
DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 36-41°F for 120-160 days (Grisez, 1974); Moist chill at 41°F for 100 days (Babb, 1959); Moist chill November thru March (Swingle, 1939)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 77°F day and 50°F night (Grisez, 1974)
GERMINATIVE ENERGY: 53% in 60 days (Monsen & Christensen, 1975)
GERMINATIVE CAPACITY: 81% in 120 days (Monsen & Christensen, 1975); 77% in 40 days (Grisez, 1974); 84% (Swingle, 1939)

CULTURAL PRACTICES

PLANTING DEPTH: 1/2" (Grisez, 1974)
PLANTING TIME: Fall or with stratified seed in spring (Grisez, 1974; Swingle, 1939); Apr (Stark, 1966)
EXPOSURE: Sun or shade (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium to coarse (Sutton & Johnson, 1974)
SOIL pH: 7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist (Sutton & Johnson, 1974)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)
NURSERY PLANTING: Rodents must be kept out of nursery, plant 25 seeds per square foot (Grisez, 1974)

PURSHIA TRIDENTATA (Pursh) DC.
(Antelope Bitterbrush)

FAMILY: Rosaceae
LIFEFORM: Native shrub to 300 cm tall (Harrington, 1964)
FRUIT: An achene 8-12 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 13,400-19,000--avg 15,400 (Dietschman et al., 1974d); 15,370 (Plummer et al., 1968); 18,000-24,000 (Hormay, 1943); 22,600 (Swingle, 1939); 18,000 (Mirov & Kraebel, 1937)
SEED MATURITY: Jul-Early Aug (Deitschman et al., 1974d; Hormay, 1943); Jun 25-Aug 15 UT (Plummer et al., 1968); Early summer (Swingle, 1939); Jul-Sep CA (Mirov & Kraebel, 1937)
METHOD OF COLLECTION: Dewing machine, fan (Deitschman et al., 1974d); Fan, Crippen EP-27, fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store dry and cool, 41°F, in burlap bags (Deitschman et al., 1974d; Hormay, 1943)
DURATION OF GOOD VIABILITY: 5 years (Deitschman et al., 1974d; Plummer et al., 1968); 14 years (Hull, 1973)
STRATIFICATION AND SCARIFICATION: Moist chill at 2°C for 4 weeks (Evans & Young, 1977); Moist chill at 35°F for 60-90 days (Neal & Sanderson, 1975); Moist chill for 1/2-3 months (Deitschman et al., 1974d); Soak in water for 2 days and germinate in 0.2% thiourea (Harper, 1970); Moist chill at 34-38°F for 30 days (McConnell, 1960); Moist chill at 31-41°F for 49-70 days, or a 50 minute soak in sulfuric acid cancels the need for stratification (Boyd, 1954); Hot water treatment inhibited germination (Peterson, 1953); Moist chill at 32-41°F for 6 weeks (Housley, 1952); Moist chill at 32-41°F for 5-8 weeks (Hormay, 1943); Moist chill for 3 months (Mirov & Kraebel, 1937)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 10-30°C day and 2-5°C night (Evans & Young, 1977); Constant at 32-38°F (Deitschman et al., 1974d); Alternating at 30°C day and 10°C night (Harper, 1970; Heit, 1968, 1970; McHenry & Jensen, 1967); Constant at 70°F (McConnell 1960; Hormay, 1943)

MOISTURE: Best at 0 bars tension, will germinate with as low as 4 bars tension (Young & Evans, 1976)

LIGHT: Does not require light (Heit, 1968); Best germination in light (McHenry & Jensen, 1967)

GERMINATIVE ENERGY: 32% in 14 days (Peterson, 1953)

GERMINATIVE CAPACITY: 83-86% in 90 days (Deitschman et al., 1974d); 73% in 14 days (Harper, 1970); 64-91% (Heit, 1970); 60% in 25 days (McHenry & Jensen, 1967); 80% in 15 days (Nord, 1965); 37% in 35 days (Peterson, 1953); 69% (Swingle, 1939); 69% in 90 days (Mirov & Kraebel, 1937)

COMMENTS: Stratification and thiourea treatments significantly improve germination (Evans & Young, 1977; Harper, 1970; Nord, 1965); 0.2% potassium nitrate solution improves germination (McHenry & Jensen, 1967); Dormancy is due to seed coat (Nord, 1965); Gibberellic acid improves germination only on unstratified seed (McConnell, 1960); Tetrazolium staining is not satisfactory for determining viability (Boyd, 1954); Susceptible to damping-off fungus (Peterson, 1953; Housley, 1952)

CULTURAL PRACTICES

PLANTING DEPTH: Drill (Evans & Young, 1977); On heavier soils 1" and lighter soils 1 1/2" (Hubbard, 1964, 1956); 1/2-1 1/2" depending on moisture (Hubbard & Sanderson, 1961); 1/2" on coarse sandy loam and 3/4" on steep slopes (Basile & Holmgren, 1957); 1/4-1 1/4" (Hormay, 1943)

PLANTING TIME: Untreated seed in fall, treated seed in fall or spring (Evans & Young, 1977; Hubbard, 1964; Hormay, 1943); Late fall or winter (Deitschman et al., 1974d); Apr-May (Stark, 1966); Fall on dry site with light soil (Hubbard, 1964); Time of planting varies with site and rainfall (Hubbard & Sanderson, 1961)

EXPOSURE: Sun (Sutton & Johnson, 1974; Hormay, 1943)

SOIL TEXTURE: Rocky (Sutton & Johnson, 1974); Variable (Stark, 1966)

SOIL pH: 6.0-7.5 (Stark, 1966)

SOIL DEPTH: Moderate to deep, 20-60" (Stark, 1966)

SOIL MOISTURE: Dry (Sutton & Johnson, 1974)

PRECIPITATION: 2-25" (15-62.5 cm) (Stark, 1966)

ORGANIC MATTER: No (Sutton & Johnson, 1974)

DRAINAGE: Well drained (Sutton & Johnson, 1974)

GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)

FIELD PLANTING: Soak seed in 3% thiourea solution at 60-140°F for 5 minutes before planting (Neal & Sanderson, 1975; Hubbard & Peterson, 1958; Pearson, 1957); Use of hydrogen peroxide treated seed may increase seedling survival through avoidance of frost kill by a two-week delay in germination (Everett & Meeuwig, 1975); Mix seed 3 lb to 8 lb rice hulls in drill (Hubbard, 1964); Stratified seed packed in ice will keep for 7-10 days (Hormay, 1943)

QUERCUS GAMBELLII Nutt.
(Gambel Oak)

FAMILY: Fagaceae

LIFEFORM: Native shrub to small tree 3-5 m tall (Harrington, 1964)

FRUIT: An acorn 12-20 mm long (Harrington, 1964)

CULTURAL PRACTICES

PLANTING TIME: Fall (Stark, 1966)

EXPOSURE: Sun (Stark, 1966)

SOIL TEXTURE: Medium to coarse (Stark, 1966)

SOIL pH: Found on limestone soil (Stark, 1966)

SOIL MOISTURE: Dry to moist (Stark, 1966)

DRAINAGE: Well drained (Stark, 1966)

NURSERY PLANTING: Easily grown (Stark, 1966)

QUERCUS TURBINELLA Greene
(Shrub Liveoak)

FAMILY: Fagaceae

LIFEFORM: Native shrub 1-3 m tall (Harrington, 1964)

FRUIT: An acorn 15-20 mm long (Harrington, 1964)

PROCUREMENT

METHOD OF COLLECTION: Collect from ground or beat shrub with canvas underneath (Olsen, 1974b)

METHOD OF CLEANING: Hand clean and sort or sort by floatation (Olsen, 1974b)

PRETREATMENT

METHOD OF STORAGE: Store in cold moist conditions 0-2°C (Hartmann & Kester, 1975)

DURATION OF GOOD VIABILITY: Impractical to store for more than 6 months (Hartmann & Kester, 1975)

STRATIFICATION AND SCARIFICATION: Moist chill at 0-2°C for 1-3 months (Hartmann & Kester, 1975)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 100°F day and 40°F night (Olsen, 1974b)

GERMINATIVE CAPACITY: 95% (Olsen, 1974b)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-1" (Olsen, 1974b)
PLANTING TIME: Fall or with stratified seed in spring (Olsen, 1974b); Spring (Stark, 1966)
EXPOSURE: Partial shade (Olsen, 1974b); Sun (Stark, 1966)
SOIL TEXTURE: Rocky (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
NURSERY PLANTING: Drill in rows 8-12" apart, mulch in fall and remove in spring (Olsen, 1974b)

RHAMNUS CATHARTICA L.
(Common Buckthorn)

FAMILY: Rhamnaceae
LIFEFORM: Introduced shrub or low tree 1-8 m tall (Harrington, 1964)
FRUIT: A berry-like drupe 7-9 mm wide with 2-4 nutlets (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 13,000-28,400--avg 19,100 (Hubbard, 1974); 23,381 (Swingle, 1939)
SEED MATURITY: Sep-Oct northeast U.S. (Hubbard, 1974)

PRETREATMENT

METHOD OF STORAGE: Store in sealed containers at 41°F (Hubbard, 1974)
STRATIFICATION AND SCARIFICATION: Moist chill at 34-41°F for 15 days (Hubbard, 1974); Stratification not necessary (Babb, 1959)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Hubbard, 1974)
GERMINATIVE CAPACITY: 90% in 30-60 days (Hubbard, 1974)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-1/2" (Hubbard, 1974)
PLANTING TIME: Fall (Hartmann & Kester, 1975); Spring (Hubbard, 1974)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)

RHUS GLABRA L.
(Smooth Sumac)

FAMILY: Anacardiaceae
LIFEFORM: Native shrub 1-2 m tall (Harrington, 1964)
FRUIT: A drupe 4 mm long with single bony nutlet (Brinkman, 1974f; Harrington, 1964)

PROCUREMENT

SEEDS/LB: 10,699-30,000--avg 20,300 (Brinkman, 1974f); 62,430 (Plummer et al., 1968); 22,090-34,432 (Swingle, 1939); 28,700 (McKeever, 1938)
SEED MATURITY: Sep-Oct (Brinkman, 1974f); Aug 5-Mar 30 UT (Plummer et al., 1968); Summer to fall (Swingle, 1939)
METHOD OF COLLECTION: Hand pick (Brinkman, 1974f); Hand pick seedheads and berry clusters into hoppers (Plummer et al., 1968)
METHOD OF CLEANING: Beat in canvas sack, fan, macerate with water (Brinkman, 1974f); Dybvig with water, dry and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store in sealed containers at 32-41°F (Brinkman, 1974f)
DURATION OF GOOD VIABILITY: 2 1/2 years (Brinkman 1974f); 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 4°C for 2 months (Hartmann & Kester, 1975); Soak in sulfuric acid at 70°F for 1-3 hours or soak in water at 212°F for 2 minutes (Brinkman, 1974f); Soak seed in sulfuric acid for 1 hour then moist chill at 41°F for 3 days (Babb, 1959); Soak in sulfuric acid for 20 minutes (Boyd, 1943); Crack seeds by hand (McKeever, 1938)

LABORATORY GERMINATION

TEMPERATURE: Constant at 68°F (Brinkman, 1974f)
LIGHT: Better germination in continuous light (Brinkman, 1974f)
GERMINATIVE ENERGY: 36% in 10 days (Brinkman, 1974f)
GERMINATIVE CAPACITY: 58% in 20-60 days (Brinkman, 1974f); 58% (Boyd, 1943); 2% (Swingle, 1939); 41% in 19 days (McKeever, 1938)
COMMENTS: Do not allow seeds to dry out (Hartmann & Kester, 1975); Dormancy is due to seed coat (McKeever, 1938)

CULTURAL PRACTICES

PLANTING DEPTH: 3/4" (Brinkmann, 1974f)
PLANTING TIME: Fall after scarification (Brinkman, 1974f)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Coarse (Sutton & Johnson, 1974); Variable (Stark, 1966)
SOIL pH: 6.5-7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Shallow to moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry to moist (Sutton & Johnson, 1974)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)

RHUS TRILOBATA Nutt.
(Skunkbush Sumac)

FAMILY: Anacardiaceae
LIFEFORM: Native shrub 50-200 cm tall (Harrington, 1964)
FRUIT: A hairy drupe 6-7 mm long with a single bony nutlet (Brinkman, 1974f; Harrington, 1964)

PROCUREMENT

SEEDS/LB: 24,000-126,000--avg 49,000 (Brinkman, 1974f): 18,895 (Plummer et al., 1968); 10,600-30,000 (Swingle, 1939)
SEED MATURITY: Aug-Sep (Brinkman, 1974f); Jun 20-Oct 10 UT (Plummer et al., 1968); Summer to early fall (Swingle, 1939)
METHOD OF COLLECTION: Hand pick (Brinkman, 1974f); Hand pick seed heads and berry clusters into hoppers (Plummer et al., 1968)
METHOD OF CLEANING: Beat in canvas sack, fan (Brinkman, 1974f); Dybvig with water, dry and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store in sealed containers at 32-41°F (Brinkman, 1974f); Dry (Swingle, 1939)
DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Soak in sulfuric acid at 70°F for 1 hour, needs a cold treatment (Brinkman, 1974f); Moist chill at 3-5°C for 1 month (Heit, 1970); Soak in sulfuric acid at 70°F for 1 hour then moist chill at 41°F for 60 days (Babb, 1959); Soak in sulfuric acid at 70°F for 1 hour (Glazebrook, 1941); If not scarified, moist chill for 120 days (Swingle, 1939)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Brinkman, 1974f)
GERMINATIVE ENERGY: 23% in 90 days (Monsen & Christensen, 1975); 61% in 15 days (Brinkman, 1974f); 70% in 8 days (Glazebrook, 1941)
GERMINATIVE CAPACITY: 43% in 180 days (Monsen & Christensen, 1975); 76% in 30 days (Brinkman, 1974f); 5-93% (Heit, 1970); 85% in 25 days (Glazebrook, 1941); 16-38% (Swingle, 1939)
COMMENTS: Degree of hardseededness and internal dormancy vary with seed source so that pretreatments may have to be altered (Heit, 1970)

CULTURAL PRACTICES

PLANTING DEPTH: 1/2" (Brinkman, 1974f)
PLANTING TIME: Fall after scarification (Brinkman, 1974f); Jan (Stark, 1966); Fall or with stratified seed in the spring (Swingle, 1939)
EXPOSURE: Shade or sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium to coarse (Sutton & Johnson, 1974)
SOIL pH: 6.5-7.5 (Sutton & Johnson, 1974)
SOIL DEPTH: Deep (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist to dry (Stark, 1966)
PRECIPITATION: 3-5" (7.5-13 cm) (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)
FIELD PLANTING: Most natural reproduction vegetative (Sanford, 1970)

RIBES AMERICANUM Mill.
(American Black Currant)

FAMILY: Grossulariaceae
LIFEFORM: Native shrub 100-150 cm tall (Harrington, 1964)
FRUIT: A berry 6-10 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 247,000-336,000--avg 313,000 (Pfister, 1974)
SEED MATURITY: Jun-Sep (Pfister, 1974)
METHOD OF COLLECTION: Hand pick or strip into container (Pfister, 1974)
METHOD OF CLEANING: Dry, ferment several days before extraction, macerate in water, dry (Pfister, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 41°F (Pfister, 1974)
DURATION OF GOOD VIABILITY: 4 years (Pfister, 1974)
STRATIFICATION AND SCARIFICATION: Moist chill at 28-36°F for 90-120 days (Pfister, 1974); Moist chill at 41-45°F for 200 days (Swingle, 1939); Sow in soil out of doors over winter (Adams, 1927)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 76% in 30-40 days (Pfister, 1974); 74% (Swingle, 1939); 74% in 202 days (Adams, 1927)

CULTURAL PRACTICES

PLANTING DEPTH: 1/8-1/4" (Pfister, 1974)
PLANTING TIME: Fall (Pfister, 1974)
ORGANIC MATTER: Yes (Pfister, 1974)
NURSERY PLANTING: Sow 40 plants per linear foot, apply 2-3" of mulch (Pfister, 1974)

RIBES AUREUM Pursh
(Golden Currant)

FAMILY: Grossulariaceae
LIFEFORM: Native shrub 100-300 cm tall (Harrington, 1964)
FRUIT: A berry 6-10 mm wide (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 200,000-285,000--avg 233,000 (Pfister, 1974); 356,180 (Plummer et al., 1968); 200,000-231,086 (Swingle, 1939)
SEED MATURITY: Jun-Jul (Pfister, 1974); Jul 20-Aug 10 UT (Plummer et al., 1968); Summer (Swingle, 1939)
METHOD OF COLLECTION: Hand pick or strip into container (Pfister, 1974); Knock from bushes onto canvas (Plummer et al., 1968)
METHOD OF CLEANING: Dry, ferment before extraction, macerate in water, dry (Pfister, 1974); Dybvig with water, dry, fan, and float (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 70°F (Pfister, 1974)
DURATION OF GOOD VIABILITY: 17 years (Pfister, 1974); 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 41°F for 60 days (Pfister, 1974); Moist chill at 41°F for 90 days (Swingle, 1939)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 63% in 30-40 days (Pfister, 1974)

CULTURAL PRACTICES

PLANTING TIME: Fall (Pfister, 1974); Fall or with stratified seed in spring (Swingle, 1939)
EXPOSURE: Sun or shade (Sutton & Johnson, 1974)
SOIL TEXTURE: Coarse to medium (Sutton & Johnson, 1974)
SOIL pH: 6.5-7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Shallow to deep (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist to dry (Sutton & Johnson, 1974)
ORGANIC MATTER: Yes (Pfister, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Sow 40 plants per linear foot, apply 2-3" mulch (Pfister, 1974)

RIBES CEREUM Dougl.
(Wax Currant)

FAMILY: Grossulariaceae
LIFEFORM: Native shrub 50-200 cm tall (Harrington, 1964)
FRUIT: A berry 6-8 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 201,000-283,000--avg 251,00 (Pfister, 1974)
SEED MATURITY: Aug (Pfister, 1974)
METHOD OF COLLECTION: Hand pick or strip into container (Pfister, 1974)
METHOD OF CLEANING: Dry, ferment before extraction, macerate in water, dry (Pfister, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 70°F (Pfister, 1974)
DURATION OF GOOD VIABILITY: 27 years (Pfister, 1974)
STRATIFICATION AND SCARIFICATION: Moist chill at 28-32°F for 120-150 days (Pfister, 1974)

LABORATORY GERMINATION

TEMPERATURE: Constant at 70°F (Griswald, 1936)
GERMINATIVE CAPACITY: 72% in 30-40 days (Pfister, 1974); 98% in 70 days (Griswald, 1936)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-1/2" (Pfister, 1974)
PLANTING TIME: Fall (Pfister, 1974)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium to coarse (Sutton & Johnson, 1974)
SOIL pH: 7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate to shallow (Sutton & Johnson, 1974)
SOIL MOISTURE: Dry (Sutton & Johnson, 1974)
ORGANIC MATTER: Yes (Pfister, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Sow 40 plants per linear foot, apply 2-3" of mulch (Pfister, 1974)

RIBES INERME Rydb.
(Whitestem Gooseberry)

FAMILY: Grossulariaceae
LIFEFORM: Native shrub to 100 cm tall (Harrington, 1964)
FRUIT: A berry approx 8 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 354,000-398,000--avg 366,000 (Pfister, 1974)
METHOD OF COLLECTION: Hand pick or strip into container (Pfister, 1974)
METHOD OF CLEANING: Dry, ferment before extraction, macerate in water, dry (Pfister, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 70°F (Pfister, 1974)
DURATION OF GOOD VIABILITY: 11 years (Pfister, 1974)
STRATIFICATION AND SCARIFICATION: Moist chill at 32°F for 120-200 days (Pfister, 1974)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 74% in 30-40 days (Pfister, 1974)

CULTURAL PRACTICES

PLANTING DEPTH: 1/8-1/4" (Pfister, 1974)
PLANTING TIME: Fall (Pfister, 1974)
ORGANIC MATTER: Yes (Pfister, 1974)
NURSERY PLANTING: Sow 40 plants per linear foot, apply 2-3" of mulch (Pfister, 1974)

RIBES LACUSTRE (Pers.) Poir
(Prickly Currant)

FAMILY: Grossulariaceae
LIFEFORM: Native shrub less than 100 cm tall (Harrington, 1964)
FRUIT: A berry 6-10 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 515,000 (Pfister, 1974)
SEED MATURITY: Aug (Pfister, 1974)
METHOD OF COLLECTION: Hand pick or strip into container (Pfister, 1974)
METHOD OF CLEANING: Dry, ferment before extraction, macerate in water, dry (Pfister, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed container (Pfister, 1974)
STRATIFICATION AND SCARIFICATION: Moist chill at 32°F for 120-200 days (Pfister, 1974)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 61% in 30-40 days (Pfister, 1974)

CULTURAL PRACTICES

PLANTING DEPTH: 1/8-1/4" (Pfister, 1974)
PLANTING TIME: Fall (Pfister, 1974)
ORGANIC MATTER: Yes (Pfister, 1974)
NURSERY PLANTING: Sow 40 plants per square foot, apply 2-3" of mulch (Pfister, 1974)

RIBES MONTIGENUM McClatchie
(Gooseberry Currant)

FAMILY: Grossulariaceae
LIFEFORM: Native shrub 30-60 cm tall (Harrington, 1964)
FRUIT: A berry 6-10 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 142,000 (Pfister, 1974); 185,595 (Plummer et al., 1968)
SEED MATURITY: Aug-Sep (Pfister, 1974); Aug 15-Sep 30 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Hand pick or strip into container (Pfister, 1974)
METHOD OF CLEANING: Dry, ferment before extraction, macerate in water, dry (Pfister, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed container (Pfister, 1974)
STRATIFICATION AND SCARIFICATION: Moist chill at 32°F for 200-300 days (Pfister, 1974)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 17% (Griswald, 1936)

CULTURAL PRACTICES

PLANTING DEPTH: 1/8-1/4" (Pfister, 1974)
PLANTING TIME: Fall (Pfister, 1974)
EXPOSURE: Sun or shade (Sutton & Johnson, 1974)
SOIL TEXTURE: Moderate to coarse (Sutton & Johnson, 1974)
SOIL pH: 6.0-7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist (Sutton & Johnson, 1974)
ORGANIC MATTER: Yes (Pfister, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Sow 40 plants per square foot, apply 2-3" of mulch (Sutton & Johnson, 1974)

RIBES VISCOSISSIMUM Pursh
(Sticky Currant)

FAMILY: Grossulariaceae
LIFEFORM: Native shrub 80-150 cm tall (Harrington, 1964)
FRUIT: A berry approx 1 cm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 255,000-349,000--avg 298,000 (Pfister, 1974)
SEED MATURITY: Aug-Sep (Pfister, 1974)
METHOD OF COLLECTION: Hand pick or strip into container (Pfister, 1974)

METHOD OF CLEANING: Dry, ferment before extraction, macerate in water, dry (Pfister, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 70°F (Pfister, 1974)
DURATION OF GOOD VIABILITY: 17 years (Pfister, 1974)
STRATIFICATION AND SCARIFICATION: Moist chill at 28-32°F for 140 days (Pfister, 1974)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 67% in 30-40 days (Pfister, 1974)

CULTURAL PRACTICES

PLANTING DEPTH: 1/8-1/4" (Pfister, 1974)
PLANTING TIME: Fall (Pfister, 1974)
EXPOSURE: Sun or shade (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium (Sutton & Johnson, 1974)
SOIL pH: 6.5-7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Deep (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist (Sutton & Johnson, 1974)
ORGANIC MATTER: Yes (Pfister, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Sow 40 plants per linear foot, apply 2-3" of mulch (Pfister, 1974)

ROSA ACICULARIS Lindl. (Prickly Rose)

FAMILY: Rosaceae
LIFEFORM: Native shrub 30-200 cm tall (Harrington, 1964)
FRUIT: A stony achene within a berry-like hip (Harrington, 1964)

PROCUREMENT

METHOD OF COLLECTION: Hand pick into containers (Gill & Pogge, 1974c)
METHOD OF CLEANING: Macerate in water, and float (Gill & Pogge, 1974c)

PRETREATMENT

METHOD OF STORAGE: Sealed container at 2-3°C (Densmore & Zasada, 1977)
STRATIFICATION AND SCARIFICATION: Warm stratify at 25°C for 115 days then moist chill at 5°C for 80-90 days, scarification not necessary if stratified (Densmore & Zasada, 1977); Soak in sulfuric acid for 1-2 hours then moist chill at 41°F for 90 days (Babb, 1959)

LABORATORY GERMINATION

TEMPERATURE: Either constant at 20°C or alternating at 20°C day and 10°C night (Densmore & Zasada, 1977)
GERMINATIVE ENERGY: 60% in 15 days (Densmore & Zasada, 1977)
GERMINATIVE CAPACITY: 92% in 28 days (Densmore & Zasada, 1977)

CULTURAL PRACTICES

PLANTING DEPTH: 2 cm (Densmore & Zasada, 1977)
PLANTING TIME: Spring for germination 1 year later (Densmore & Zasada, 1977)

ROSA ARKANSANA Porter (Arkansas Rose)

FAMILY: Rosaceae
LIFEFORM: Native shrub 10-40 cm tall (Harrington, 1964)
FRUIT: A stony achene within a berry-like hip (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 24,540 (Swingle, 1939)

ROSA MULTIFLORA Thunb. (Multiflora Rose)

FAMILY: Rosaceae
LIFEFORM: Introduced shrub (Bailey, 1949)
FRUIT: A stony achene within a berry-like hip (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 50,000-81,536 (Swingle, 1939)

PRETREATMENT

STRATIFICATION AND SCARIFICATION: Moist chill at 40°F for 2 weeks (Stark, 1966); Soak in sulfuric acid for 1-2 hours then moist chill at 41°F for 75 days (Babb, 1959); Moist chill at 40°F for 60 days (Swingle, 1939)

CULTURAL PRACTICES

PLANTING TIME: Early spring (Swingle, 1939)
SOIL TEXTURE: Variable (Stark, 1966)
SOIL DEPTH: Moderate to deep (Stark, 1966)
SOIL MOISTURE: Moist to dry (Stark, 1966)
NURSERY PLANTING: Easily grown

ROSA NUTKANA Presl. (Nootka Rose)

FAMILY: Rosaceae
LIFEFORM: Native shrub usually over 100 cm (Harrington, 1964)
FRUIT: A stony achene within a berry-like hip (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 30,000-60,000 (Gill & Pogge, 1974c); 30,000-53,146 (Swingle, 1939); 60,200 (McKeever, 1938); 30,000 (Mirov & Kraebel, 1937)
SEED MATURITY: Aug-Sep northern ID (Gill & Pogge, 1974c); Fall (Swingle, 1939); Sep CA (Mirov & Kraebel, 1937)
METHOD OF COLLECTION: Hand pick into container (Gill & Pogge, 1974c)
METHOD OF CLEANING: Macerate in water and float (Gill & Pogge, 1974c)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 34-38°F (Gill & Pogge, 1974c); Store day at 15.5-21°C, exposure of fruit to low temperatues may decrease germination (Semeniuk & Stewart, 1966)
DURATION OF GOOD VIABILITY: 2-4 years (Gill & Pogge, 1974c); Less than 4 years (King, 1947)
STRATIFICATION AND SCARIFICATION: Moist chill at 34-41°F for 140 days (Gill & Pogge, 1974c); Store at 1.5-18.5°C for 128 days then moist chill at 4.5°C for 128 days until germination (Semeniuk & Stewart, 1966); Moist chill for 3 months (Swingle, 1939); Moist chill at 4.5°C for 128 days or until germination (McKeever, 1938)

LABORATORY GERMINATION

TEMPERATURE: Constant at 70°F (Gill & Pogge, 1974c); Constant at 4.5-7°C Semeniuk & Stewart, 1966)
MOISTURE: Moist (Semeniuk & Steward, 1966)
GERMINATIVE CAPACITY: 63% in 36 days (Gill & Pogge, 1974c): 63-72% in 128 days (Seminiuk & Stewart, 1966); 50% (Swingle, 1939); 44% in 18 days (McKeever, 1938); 50% in 100 days Mirov & Kraebel, 1937)
COMMENTS: Dormancy due to dormant or immature embryo (McKeever, 1938)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-3/4" (Gill & Pogge, 1974c)
PLANTING TIME: Fall (Gill & Pogge, 1974c); Spring (Swingle, 1939)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Coarse (Sutton & Johnson, 1974)
SOIL pH: 6.0-7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Shallow to moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist (Sutton & Johnson, 1974)
ORGANIC MATTER: If possible (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Apply mulch (Sutton & Johnson, 1974)

ROSA WOODSII Lindl.
(Woods Rose)

FAMILY: Rosaceae
LIFEFORM: Native shrub 50-300 cm tall (Harrington, 1964)
FRUIT: A stony achene 3-4 mm long within a berry-like hip 6-15 mm wide (Blauer et al., 1975)

PROCUREMENT

SEEDS/LB: 35,000-65,000--avg 50,000 (Gill & Pogge, 1974c); 45,300 (Plummer et al., 1968)
SEED MATURITY: Jul 1-Aug 15 SD (Gill & Pogge, 1974c); Sep 1-Nov 30 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Hand pick into container (Gill & Pogge, 1974c); Knock or beat into hoppers or containers (Plummer et al., 1968)
METHOD OF CLEANING: Macerate in water and float off pulp (Gill & Pogge, 1974c); Dybvig with water, dry, and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 34-38°F (Gill & Pogge, 1974c)
DURATION OF GOOD VIABILITY: 2-4 years (Gill & Pogge, 1974c); 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill one month (Milstein & Milstein, 1976); Warm stratify then cold stratify (Gill & Pogge, 1974c)

LABORATORY GERMINATION

LIGHT: Best in light (Milstein & Milstein, 1976)
GERMINATIVE CAPACITY: Complete in 30-40 days (Milstein & Milstein, 1976)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4-3/4" (Gill & Pogge, 1974c)
PLANTING TIME: Fall (Gill & Pogge, 1974c)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Medium to moderately fine (Stark, 1966)
SOIL pH: Slight saline-alkaline tolerance (Stark, 1966)
SOIL DEPTH: Deep (Stark, 1966)
SOIL MOISTURE: Dry to moist (Stark, 1966)
NURSERY PLANTING: Apply mulch (Gill & Pogge, 1974c)

RUBUS LEUCODERMIS Dougl.
Whitebark Raspberry)

FAMILY: Rosaceae
LIFEFORM: Native shrub 3-9 feet tall (Vines, 1960)

FRUIT: An aggregate of small drupes up to 3/5" across (Vines, 1960)

PROCUREMENT

SEEDS/LB: 422,168 (Swingle, 1939)
SEED MATURITY: Jul-Sep southwestern U.S. (Vines, 1960)

RUBUS OCCIDENTALIS L.
(Blackcap Raspberry)

FAMILY: Rosaceae
LIFEFORM: Native shrub 3-7 1/2' tall (Vines, 1960)
FRUIT: An aggregate of drupes up to 3/5" across (Vines, 1960)

PROCUREMENT

SEEDS/LB: 286,000-384,000--avg 334,000 (Brinkman, 1974g); 384,000 (Swingle, 1939)
SEED MATURITY: Jun-Aug (Brinkman, 1974g); Summer (Swingle, 1939)
METHOD OF COLLECTION: Hand pick into container (Brinkman, 1974g)
METHOD OF CLEANING: Macerate in water, float off pulp, screen and dry (Brinkman, 1974g)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Brinkman, 1974g)
STRATIFICATION AND SCARIFICATION: Soak in sulfuric acid for 50-60 minutes then moist chill at 36-41°F for 90 days (Brinkman, 1974g)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 78-80°F day and 68-70°F night (Brinkman, 1974g)
GERMINATIVE ENERGY: 44-78% in 7-8 days (Brinkman, 1974g)
GERMINATIVE CAPACITY: 64% in 30-40 days (Brinkman, 1974g)

CULTURAL PRACTICES

PLANTING DEPTH: 1/8-3/16" (Brinkman, 1974g)
PLANTING TIME: Late summer or with stratified seed in the fall (Brinkman, 1974g)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)
NURSERY PLANTING: Drill seed, mulch over winter (Brinkman, 1974g)

RUBUS STRIGOSUS Michx.
(American Red Raspberry)

SYNONOMY: *Rubus idaeus strigosus, Rubus idaeus melanolasius, Rubus melanolasius*
FAMILY: Rosaceae
LIFEFORM: Native shrub 4"-6' tall (Vines, 1960)
FRUIT: An aggregate of drupes 10-12 mm wide (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 384,000 (Swingle, 1939)
SEED MATURITY: Jun-Oct southwestern U.S. (Vines, 1960)

SALIX BEBBIANA Sarg.
(Bebb Willow)

FAMILY: Salicaceae
LIFEFORM: Native shrub or small tree 2-8 m tall (Harrington, 1964)
FRUIT: A capsule 6-8 mm long within an ament 2-4 cm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 2,500,000 (Brinkman, 1974h)
SEED MATURITY: May-Jun (Brinkman, 1974h)
METHOD OF COLLECTION: Hand pick or collect in drifts (Brinkman, 1974h)
METHOD OF CLEANING: Not necessary (Brinkman, 1974h)

PRETREATMENT

METHOD OF STORAGE: Store moist in sealed containers at 32-41°F for one month (Brinkman, 1974h)
DURATION OF GOOD VIABILITY: Seed viable up to 10 days at 70°F and 4-6 weeks moist at 32-41°F (Brinkman, 1974h)
STRATIFICATION AND SCARIFICATION: None necessary (Brinkman, 1974h)

LABORATORY GERMINATION

TEMPERATURE: Alternating 86°F day and 68°F night (Brinkman, 1974h)
LIGHT: Light is required (Brinkman, 1974h)
GERMINATIVE ENERGY: 27% in 2 days (Brinkman, 1974h)
GERMINATIVE CAPACITY: 28% in 7 days (Brinkman, 1974h)
COMMENTS: Viability decreases rapidly with age (Brinkman, 1974h)

CULTURAL PRACTICES

PLANTING TIME: As soon as seed is ripe (Swingle, 1939)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium to coarse (Sutton & Johnson, 1974)
SOIL pH: 7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Wet (Sutton & Johnson, 1974)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Boggy or wet (Sutton & Johnson, 1974)

SALIX EXIGUA Nutt.
(Coyote Willow)

FAMILY: Salicaceae
LIFEFORM: Native shrub or small tree 2-8 m tall (Harrington, 1964)
FRUIT: A capsule 5 mm long within an ament 3-6 cm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 10,000,000 (Brinkman, 1974h)
SEED MATURITY: Jun-Jul (Brinkman, 1974h)
METHOD OF COLLECTION: Hand pick or collect in drifts (Brinkman, 1974h)
METHOD OF CLEANING: None necessary (Brinkman, 1974h)

PRETREATMENT

METHOD OF STORAGE: Store moist in sealed containers at 32-41°F for one month (Brinkman, 1974h)
DURATION OF GOOD VIABILITY: Seed is viable up to 10 days at 70°F and 4-6 weeks at 32-41°F (Brinkman, 1974h)
STRATIFICATION AND SCARIFICATION: None necessary (Brinkman, 1974h)

LABORATORY GERMINATION

TEMPERATURE: Constant at 72°F (Brinkman, 1974h)
LIGHT: Light is required (Brinkman, 1974h)
GERMINATIVE ENERGY: 83% in 4 days (Brinkman, 1974h)
GERMINATIVE CAPACITY: 83% in 4 days (Brinkman, 1974h)
COMMENTS: Viability decreases rapidly with age (Brinkman, 1974h)

CULTURAL PRACTICES

PLANTING TIME: Spring (Stark, 1966); As soon as possible (Swingle, 1939)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium to coarse, variable (Sutton & Johnson, 1974)
SOIL pH: 7.0-8.0, slight saline-alkaline tolerance (Stark, 1966)
SOIL DEPTH: Moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist to wet (Sutton & Johnson, 1974)
PRECIPITATION: 4-10" (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Wet or boggy (Sutton & Johnson, 1974)

SALIX INTERIOR Rowlee
(Sandbar Willow)

FAMILY: Salicaceae
LIFEFORM: Native shrub or small tree 1-8 mm tall (Harrington, 1964)
FRUIT: A capsule within an ament 2-5 cm long and 1 cm wide (Harrington, 1964)

PROCUREMENT

SEED MATURITY: May-Jun (Brinkman, 1974h)
METHOD OF COLLECTION: Hand pick or collect in drifts (Brinkman, 1974h)
METHOD OF CLEANING: None necessary (Brinkman, 1974h)

PRETREATMENT

METHOD OF STORAGE: Store moist in sealed containers at 32-41°F for one month (Brinkman, 1974h)
DURATION OF GOOD VIABILITY: Seed viable up to 10 days at 70°F and 4-6 weeks moist at 32-41°F (Brinkman, 1974h)
STRATIFICATION AND SCARIFICATION: None necessary (Brinkman, 1974h)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 85°F day and 70°F night (Brinkman, 1974h)
LIGHT: Light is required (Brinkman, 1974h)
GERMINATIVE ENERGY: 80% in 3 days (Brinkman, 1974h)
GERMINATIVE CAPACITY: 80% in 12 days (Brinkman, 1974h)
COMMENTS: Viability decreases rapidly with age (Brinkman, 1974h)

CULTURAL PRACTICES

PLANTING TIME: As soon as seed is ripe (Swingle, 1939)

SALIX PETIOLARIS J. E. Sm.
(Meadow Willow)

FAMILY: Salicaceae
LIFEFORM: Native shrub 2-4 m tall (Harrington, 1964)
FRUIT: A capsule 3-4 mm long within an ament 1.5-2 cm long and 1 cm wide (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 500,000 (Brinkman, 1974h)
SEED MATURITY: Jun-Jul (Brinkman, 1974h)
METHOD OF COLLECTION: Hand pick or collect in drifts (Brinkman, 1974h)
METHOD OF CLEANING: None necessary (Brinkman, 1974h)

PRETREATMENT

METHOD OF STORAGE: Store moist in sealed containers at 32-41°F for one month (Brinkman, 1974h)
DURATION OF GOOD VIABILITY: Seed is viable up to 10 days at 70°F and 4-6 weeks moist at 32-41°F (Brinkman, 1974h)
STRATIFICATION AND SCARIFICATION: None necessary (Brinkman, 1974h)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Brinkman, 1974h)
LIGHT: Light is required (Brinkman, 1974h)
GERMINATIVE ENERGY: 80% in 2 days (Brinkman, 1974h)
GERMINATIVE CAPACITY: 82% in 3 days (Brinkman, 1974h)
COMMENTS: Viability decreases rapidly with age (Brinkman, 1974h)

CULTURAL PRACTICES

PLANTING TIME: As soon as seed is ripe (Swingle, 1939)

SALIX SCOULERIANA Barratt in Hook.
(Scouler Willow)

FAMILY: Salicaceae
LIFEFORM: Native shrub or small tree 3-10 mm tall (Harrington, 1964)
FRUIT: A capsule 7-9 mm long within an ament 3-8 cm thick (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 6,500,000 (Brinkman, 1974h)
SEED MATURITY: May-Jul (Brinkman, 1974h); Spring (Swingle, 1939)
METHOD OF COLLECTION: Hand pick or collect in drifts (Brinkman, 1974h)
METHOD OF CLEANING: None necessary (Brinkman, 1974h)

PRETREATMENT

METHOD OF STORAGE: Store moist in sealed containers at 32-41°F for one month (Brinkman, 1974h)
DURATION OF GOOD VIABILITY: Seed is viable up to 10 days at 70°F and 4-6 weeks moist at 32-41°F (Brinkman, 1974h)
STRATIFICATION AND SCARIFICATION: None necessary (Brinkman, 1974h)

LABORATORY GERMINATION

TEMPERATURE: Alternating 85°F day and 70°F night (Brinkman, 1974h)
LIGHT: Light is required (Brinkman, 1974h)
GERMINATIVE ENERGY: 95% in 1 day (Brinkman, 1974h)
GERMINATIVE CAPACITY: 95% in 2 days (Brinkman, 1974h)
COMMENTS: Viability decreases rapidly with age (Brinkman, 1974h)

CULTURAL PRACTICES

PLANTING TIME: As soon as seed is ripe (Swingle, 1939)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium (Sutton & Johnson, 1974)
SOIL pH: 6.5-7.0 (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist to dry (Sutton & Johnson, 1974)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
FIELD PLANTING: Most reproduction in nature is vegetative (Sampson, 1917)

SAMBUCUS CANADENSIS L.
(American Elder)

FAMILY: Caprifoliaceae
LIFEFORM: Native shrub 1-3 m tall (Harrington, 1964)
FRUIT: A berry-like pome 4-5 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 175,000-324,000--avg 232,000 (Brinkman, 1974i); 202,000-468,220 (Swingle, 1939)
SEED MATURITY: Jul-Sep (Brinkman, 1974i); Summer to fall (Swingle, 1939)
METHOD OF COLLECTION: Strip or cut clusters of berries from branches (Brinkman, 1974i)
METHOD OF CLEANING: Macerate with water, float off, dry, fan and screen (Brinkman, 1974i)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Brinkman, 1974i); Seed must be removed from pulp before storage (Davis, 1927)
DURATION OF GOOD VIABILITY: 2 years (Brinkman, 1974i)
STRATIFICATION AND SCARIFICATION: Warm stratify at 86°F day and 68°F night for 60 days then moist chill at 41°F for 90-150 days (Brinkman, 1974i); Warm stratify at 77°F for 60 days then moist chill at 41°F for 90 days (Babb, 1959); Layer fresh seed out of doors over winter (Adams, 1927; Rose, 1919); Moist chill at 0-5°C for 85-100 days (Davis, 1927)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Brinkman, 1974i); Alternating at 27°C day and 10°C night (Davis, 1927)
MOISTURE: Moist (Rose, 1919)
GERMINATIVE ENERGY: 32% in 16 days (Brinkman, 1974i)
GERMINATIVE CAPACITY: 63% in 60 days (Brinkman, 1974i); 13% (Swingle, 1939); 57% in 25-70 days (Nichols, 1934); 92-95% in 299 days (Adams, 1927); 60-70% (Davis, 1927); 77% (Rose, 1919)
COMMENTS: Exposure to warm temperatures during stratification will induce secondary dormancy which can be overcome by an additional 130-140 days of cold stratification (Davis, 1927)

CULTURAL PRACTICES

PLANTING TIME: Immediately after harvest or in spring after stratification (Swingle, 1939); Fall (Adams, 1927; Davis, 1927)
EXPOSURE: Protect from freezing (Davis, 1927)
GREENHOUSE PLANTING: Reproduced well from cuttings (Swingle, 1939)

SAMBUCUS COERULEA Raf.
(Blueberry Elder)

SYNONOMY: *Sambucus glauca*
FAMILY: Caprifoliaceae
LIFEFORM: Native large shrub or small tree 2-6 m tall (Harrington, 1964)
FRUIT: A berry-like drupe 5-6 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 117,000-259,000--avg 205,000 (Brinkman, 1974i); 216,770 (Plummer et al., 1968); 117,000-126,088 (Swingle, 1939); 137,400 (McKeever, 1938)
SEED MATURITY: Aug-Sep (Brinkman, 1974i); Aug 15-Sep 25 UT (Plummer et al., 1968); Late summer (Swingle, 1939)
METHOD OF COLLECTION: Strip or cut clusters of berries from branches (Brinkman, 1974i); Hand pick into containers (Swingle, 1939)
METHOD OF CLEANING: Macerate with water, float off, dry, fan, and screen (Brinkman, 1974i); Dybvig with water, dry, fan, and float (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Brinkman, 1974i); Dry (Swingle, 1939)
DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Moist chill at 41°F for 98 days (Brinkman, 1974i); Stratification may help (Stark, 1966; Swingle, 1939); Moist chill in sand at 5°C for 16 weeks to 64 weeks (McKeever, 1938)

LABORATORY GERMINATION

TEMPERATURE: Constant at 70°F (Brinkman, 1974i)
GERMINATIVE ENERGY: 20% in 120 days (Monsen & Christensen, 1975); 55% in 12 days (Brinkman, 1974i); 62% in 13 days (McKeever, 1938)
GERMINATIVE CAPACITY: 33% in 120 days (Monsen & Christensen, 1975); 75% in 35 days (Brinkman, 1974i); 64-80% in 20-23 days (McKeever, 1938)
COMMENTS: Dormancy is due to dormant or immature embryo (McKeever, 1938)

CULTURAL PRACTICES

PLANTING TIME: Fall (Monsen & Christensen, 1975); Spring after stratification (Swingle, 1939)
EXPOSURE: Sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium to coarse (Sutton & Johnson, 1974)
SOIL pH: 7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Deep (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist-dry (Sutton & Johnson, 1974)
ORGANIC MATTER: Yes (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
GEENHOUSE PLANTING: Reproduces fairly well from cuttings (Swingle, 1939)

SAMBUCUS MELANOCARPA A. Gray
(Mountain Elder)

FAMILY: Caprifoliaceae
LIFEFORM: Native shrub up to 3 m tall (Harrington, 1964)
FRUIT: A berry-like drupe approx 6 mm in diameter (Harrington, 1964)

PROCUREMENT

SEED MATURITY: Aug 20-Sep 15 (Sampson, 1917)

CULTURAL PRACTICES

EXPOSURE: Sun (Sampson, 1917)
SOIL TEXTURE: Coarse (Sampson, 1917)
SOIL MOISTURE: Moist (Sampson, 1917)

SAMBUCUS RACEMOSA L.
(Scarlet Elder)

SYNONOMY: *Sambucus pubens, Sambucus racemosa* spp. *pubens*, var. *microbotrys, Sambucus microbotrys*
FAMILY: Caprifoliaceae
LIFEFORM: Native shrub 60-400 cm tall (Harrington, 1964)
FRUIT: A berry-like drupe approx 5 mm in diameter (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 192,000-377,000--avg 286,000 (Brinkman, 1974i); 303,000 (Swingle, 1939)
SEED MATURITY: Jun-Aug (Brinkman, 1974i); Jun-Nov southwest U.S. (Vines, 1960); Summer to fall (Swingle, 1939)
METHOD OF COLLECTION: Strip or cut clusters from branches (Brinkman, 1974i)
METHOD OF CLEANING: Macerate with water, float off, dry, fan, and screen (Brinkman, 1974i)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Brinkman, 1974i)

STRATIFICATION AND SCARIFICATION: Warm stratify at 86°F day and 68°F night for 30-60 days then moist chill at 41°F for 90-150 days (Brinkman, 1974i); Moist chill at 2°C for 5 months (Conrad & McDonough, 1972; McDonough, 1969); Does not need stratification (Nichols, 1934)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Brinkman, 1974i); Alternating at 25°C day and 15°C night (Conrad & McDonough, 1972); Alternating at 22°C day and 17°C night (McDonough, 1969); Constant at 70°F (Griswald, 1936)

GERMINATIVE ENERGY: 50% in 2 days (McDonough, 1969)

GERMINATIVE CAPACITY: 47% in 60 days (Brinkman, 1974i); 37-51% in 30 days (Conrad & McDonough, 1972); 100% in 28 days (McDonough, 1969); 6% (Griswald, 1936); 51% in 139-252 days (Nichols, 1934)

COMMENTS: Both a seed coat and embryo dormancy (Vines, 1960)

CULTURAL PRACTICES

PLANTING DEPTH: Drill 1/4" (Vines, 1960)

PLANTING TIME: Fall or with stratified seed in spring (Swingle, 1939)

EXPOSURE: Seedlings should have half shade (Vines, 1960)

GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)

FIELD PLANTING: Redproduces best vegetatively (Conrad & McDonough, 1972)

SARCOBATUS VERMICULATUS (Hook.) Torr.
(Black Greasewood)

FAMILY: Chenopodiaceae

LIFEFORM: Native shrub 30-300 cm tall (Harrington, 1964)

FRUIT: A utricle with wings 6-13 mm wide (Blauer et al., 1976)

PROCUREMENT

SEEDS/LB: 193,000-257,000 (Eddleman, 1977); 285,600 (Blauer et al., 1976)

SEED MATURITY: Late Sep-mid Nov MT (Eddleman, 1977)

METHOD OF COLLECTION: Knock seed from plant with flail onto convas (Eddleman, 1977)

METHOD OF CLEANING: Mechanical flail, clipper 8/(1/25), seed blower (Eddleman, 1977)

LABORATORY GERMINATION

TEMPERATURE: Either constant at 20°C or alternating at 20°C day and 5°C night (Eddleman, 1977)

LIGHT: Light may be beneficial (Eddelman, 1977)

GERMINATIVE ENERGY: 50% in 1-6 days (Eddleman, 1977)

GERMINATIVE CAPACITY: 67-72% (Eddleman, 1977); 16% (Swingle, 1939)

CULTURAL PRACTICES

EXPOSURE: Sun (Blauer et al., 1976)

SOIL TEXTURE: Fine (Blauer et al., 1976)

SOIL pH: High alkali tolerance (Blauer et al., 1976)

SOIL SALINITY: High salt tolerance (Blauer et al., 1976)

SOIL MOISTURE: Dry (Blauer et al., 1976)

SHEPHERDIA ARGENTEA (Pursh) Nutt.
(Silver Buffaloberry)

FAMILY: Elaeagnaceae

LIFEFORM: Native shrub or small tree 2-7 m tall (Harrington, 1964)

FRUIT: A drupe-like achene 1/8-1/4" long (Thilenius et al., 1974)

PROCUREMENT

SEEDS/LB: 18,000-67,000--avg 41,000 (Thilenius et al., 1974); 10,980 (Plummer et al., 1968); 18,000-67,000 (Swingle, 1939); 18,000 (Mirov & Kraebel, 1937)

SEED MATURITY: Jun-Aug (Thilenius et al., 1974); Late summer or fall (Swingle, 1939); Aug 1-Sep 30 CA (Mirov & Kraebel, 1937)

METHOD OF COLLECTION: Strip or flail bush onto canvas, use heavy gloves (Thilenius et al., 1974)

METHOD OF CLEANING: Screen, macerate with water, float-off, dry (Thilenius et al., 1974); Dybvig with water, dry and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Thilenius et al., 1974)

DURATION OF GOOD VIABILTY: 4 1/2 years (Thilenius et al., 1974); 5 years (Plummer et al., 1968)

STRATIFICATION AND SCARIFICATION: Moist chill at 41°F for 90 days (Thilenius et al., 1974); Soak in sulfuric acid for 20-30 minutes, stratification unnecessary after an acid soak although stratification gives more rapid germination (Heit, 1970)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Thilenius et al., 1974); Alternating at 30°C day and 20°C night (Heit, 1970)

LIGHT: Best in light (Heit, 1970)

GERMINATIVE ENERGY: 93% in 18 days (Thilenius et al., 1974)

GERMINATIVE CAPACITY: 16% in 60 days (Thilenius et al., 1974); 71-86% in 21 days

(Heit, 1970); 12-78% (Swingle, 1939); 78% in 38 days (Mirov & Kraebel, 1937)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Thilenius et al., 1974)
PLANTING TIME: Fall or with stratified seed in spring (Swingle, 1939)
EXPOSURE: Sun (Sutton & Johnson, 1974); Sun or shade (Stark, 1966)
SOIL TEXTURE: Medium to coarse or fine (Sutton & Johnson, 1974)
SOIL pH: 7.0-8.0 (Stark, 1966)
SOIL SALINITY: Slight saline tolerance (Stark, 1966)
SOIL DEPTH: Deep (Stark, 1966)
SOIL MOISTURE: Moist to dry (Stark, 1966)
PRECIPITATION: 6-12" (Stark, 1966)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
GREENHOUSE PLANTING: Vegetative propagation best with 2" branch tips in a frame with bottom heat (Mirov & Kraebel, 1939); Reproduces well from cuttings (Swingle, 1939)
NURSERY PLANTING: Apply mulch 1/2-1" deep over seedbed (Thilenius et al., 1974)

SHEPHERDIA CANADENSIS (L.) Nutt. (Russet Buffaloberry)

FAMILY: Elaeagnaceae
LIFEFORM: Native shrub 1-3 m tall (Harrington, 1964)
FRUIT: A drupe-like achene 1/8-1/4" long (Thilenius et al., 1974)

PROCUREMENT

SEEDS/LB: 59,215 (Plummer et al., 1968)
SEED MATURITY: Jun-Aug (Thilenius et al., 1974); Jul 15-Aug 30 UT (Plummer et al., 1968)
METHOD OF COLLECTION: Strip or flail bush onto canvas (Thilenius et al., 1974)
METHOD OF CLEANING: Screen, macerate with water, float-off, dry (Thilenius et al., 1974); Dybvig with water, dry, and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Thilenius et al., 1974)
DURATION OF GOOD VIABILITY: 5 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: Soak in sulfuric acid for 20-30 minutes (Thilenius et al., 1974); Soak in sulfuric acid for 30 minutes, stratification not necessary after acid soak (Heit, 1970); Moist chill at 1°C for 60 days, scarification not necessary (McLean, 1967); Moist chill at 41°F for 75 days (Babb, 1959)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Thilenius et al., 1974); Alternating at 30°C day and 20°C night (Heit, 1970)
GERMINATIVE CAPACITY: 80% in 21 days (Thilenius et al., 1974); 68% (McLean, 1967)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Thilenius et al., 1974)
PLANTING TIME: Fall or with stratified seed in spring (Swingle, 1939)
EXPOSURE: Usually shaded (Harrington, 1964)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)
NURSERY PLANTING: Apply mulch 1/2-1" deep over seedbed (Swingle, 1939)

SORBUS SCOPULINA Greene (Greene's Mountain Ash)

FAMILY: Rosaceae
LIFEFORM: Native shrub 4-5 m tall (Harrington, 1964)
FRUIT: A fleshy 4-seeded pome over 2 cm wide (Harrington, 1964)

PROCUREMENT

METHOD OF COLLECTOIN: Hand pick or shake onto canvas (Harris & Stein, 1974)
METHOD OF CLEANING: Macerate in water, float-off, dry, and fan (Harris & Stein, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 34-38°F (Harris & Stein, 1974)
STRATIFICATION AND SCARIFICATION: Moist chill at 33-41°F for 60 days (Harris & Stein, 1974); Warm stratify at 77°F for 115 days then moist chill at 41°F for 75 days (Babb, 1959)

CULTURAL PRACTICES

PLANTING DEPTH: 1/16" (Harris & Stein, 1974)
PLANTING TIME: Fall or early winter (Harris & Stein, 1974); Spring (Stark, 1966)
EXPOSURE: Sun or shade (Stark, 1966)
SOIL TEXTURE: Medium (Stark, 1966)
SOIL DEPTH: Deep (Stark, 1966)
SOIL MOISTURE: Moist (Stark, 1966)
ORGANIC MATTER: Yes (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)
FIELD PLANTING: Drill cleaned seed, many seeds will not germinate until 2nd or 3rd season (Harris & Stein, 1974)

SPIRAEA CAESPITOSA Nutt.
(Dwarf Spiraea)

SYNONOMY: *Petrophytum caespitosum*
FAMILY: Rosaceae
LIFEFORM: Native prostrate shrub (Harrington, 1964)
FRUIT: A follicle approx 2 mm long (Harrington, 1964)

CULTURAL PRACTICES

PLANTING TIME: Spring (Stark, 1966)
SOIL TEXTURE: Medium (Stark, 1966)
SOIL MOISTURE: Dry to slightly moist (Stark, 1966)
DRAINAGE: Well drained (Stark, 1966)
FIELD PLANTING: Not easily grown (Hitchcock & Cronquist, 1973)

SYMPHORICARPOS ALBUS ALBUS (L.) Blake
(Common Snowberry)

SYNONOMY: *Symphoricarpos racemosus*
FAMILY: Caprifoliaceae
LIFEFORM: Native shrub 20-80 cm tall (Harrington, 1964)
FRUIT: A 2-seeded, berry-like drupe 6-10 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 54,000-113,000--avg 76,000 (Evans, 1974); 65,175 (Glazebrook, 1941); 53,600-95,650 (Swingle, 1939); 54,000, 18,000 dry fruits (Mirov & Kraebel, 1937)
SEED MATURITY: Aug 1-Sep 5 ID (Evans, 1974); Fall (Swingle, 1939); Oct-Nov CA (Mirov & Kraebel, 1937)
METHOD OF COLLECTION: Strip or flail clusters from branches onto canvas (Evans, 1974)
METHOD OF CLEANING: Macerate with water and float-off, dry and fan (Evans, 1974); Depulp in #1 Be-1 hammermill, wash in water, dry at 70°F, clipper clean (Glazebrook, 1941)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Evans, 1974); Dry in cloth bags at 70°F (Glazebrook, 1941)
STRATIFICATION AND SCARIFICATION: Soak seed in sulfuric acid for 75 minutes then warm stratify at 86°F for 20 days then moist chill at 41°F for 180 days (Evans, 1974); Soak in sulfuric acid for 75 minutes (Babb, 1959); Warm stratify at 25°C for 3-4 months then moist chill at 5°C for 6 months (Flemion, 1942); Moist chill at least 100-140 days, may benefit from 1 hour soak in sulfuric acid (Glazebrook, 1941); Soak seed in sulfuric acid for 75 minutes, needs both warm and cold stratification (Swingle, 1939); Soak seed in sulfuric acid for 1 hour then moist chill for 6 months (Mirov & Kraebel, 1937); Sow in soil out of doors over winter (Adams, 1927)

LABORATORY GERMINATION

TEMPERATURE: Alternating at 86°F day and 68°F night (Evans, 1974); Temperature sensitive (Glazebrook, 1941)
MOISTURE: Moisture sensitive (Glazebrook, 1941)
GERMINATIVE CAPACITY: 35% in 30 days (Evans, 1974); 2-32% (Glazebrook, 1941); 75% (Swingle, 1939); 50% in 640 days (Adams, 1927)
COMMENTS: Addition of nitrogen compounds to the peat moss during the period of warm stratification aids germination (Flemion, 1942); Germination may occur during stratification, method of overcoming dormancy poorly understood (Glazebrook, 1941); Germination is enhanced by fungal decay of outer seed coat which is in turn enhanced by a soak in sulfuric acid (Pfeiffer, 1934)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Evans, 1974)
PLANTING TIME: Fall (Glazebrook, 1941)
NURSERY PLANTING: Warm stratify seed and sow in fall, mulch with 3/4" sawdust (Evans, 1974); Stems are easily rooted in open (Mirov & Kraebel, 1939)
FIELD PLANTING: Propagation by seed is difficult, it can easily be propagated by cuttings (Swingle, 1939; Mirov & Kraebel, 1937)

SYMPHORICARPOS LONGIFLORUS Gray
(Longflower Snowberry)

FAMILY: Caprifoliaceae
LIFEFORM: Native shrub 50-100 cm tall (Harrington, 1964)
FRUIT: A 2-seeded, berry-like drupe 8-10 mm long (Harrington, 1964)

PROCUREMENT

METHOD OF COLLECTION: Strip or flail clusters from branches onto canvas (Evans, 1974)
METHOD OF CLEANING: Macerate with water and float-off, dry and fan (Evans, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Evans, 1974)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Evans, 1974)
PLANTING TIME: Sow unstratified seed in fall (Evans, 1974); Spring (Stark, 1966)
EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Medium to coarse (Stark, 1966)
SOIL pH: Often on limestone (Stark, 1966)

SOIL DEPTH: 20-60" (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
PRECIPITATION: 8-14" (Stark, 1966)
NURSERY PLANTING: Stems easily rooted in open (Mirov & Kraebel, 1939)

SYMPHORICARPOS OCCIDENTALIS Hook. (Western Snowberry)

FAMILY: Caprifoliaceae
LIFEFORM: Native shrub 50-150 cm tall (Harrington, 1964)
FRUIT: A 2-seeded, berry-like drupe 6-8 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 52,000-98,700--avg 74,400 (Evans, 1974); 52,000-77,606 (Swingle, 1939)
SEED MATURITY: Jun 1-Jul 31 SD (Evans, 1974); Fall (Swingle, 1939)
METHOD OF COLLECTION: Strip or flail clusters from branches onto canvas (Evans, 1974)
METHOD OF CLEANING: Macerate with water, float off, dry, and fan (Evans, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Evans, 1974)
STRATIFICATION AND SCARIFICATION: Moist chill for 270 days (Evans, 1974)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Evans, 1974)
PLANTING TIME: Fall (Evans, 1974); Summer or stratify (Swingle, 1939)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)
NURSERY PLANTING: Warm stratify seed and sow in fall, mulch seedbed with 3/4" sawdust (Evans, 1974); Stems easily rooted in open (Mirov & Kraebel, 1939)

SYMPHORICARPOS ORBICULATUS Moench (Indian Currant)

FAMILY: Caprifoliaceae
LIFEFORM: Native shrub 2-6 ft tall (Vines, 1960)
FRUIT: A 2-seeded, berry-like drupe 1/6-1/4" thick (Vines, 1960)

PROCUREMENT

SEEDS/LB: 135,000-144,000--avg 140,000 (Evans, 1974); 407,680 (Swingle, 1939)
SEED MATURITY: Jul 1-Aug 31 (Evans, 1974); Fall (Swingle, 1939)
METHOD OF COLLECTION: Strip or flail clusters from branches onto canvas (Evans, 1974)
METHOD OF CLEANING: Macerate with water, float off, dry and fan (Evans, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Evans, 1974); 10°F (Flemion & Parker, 1942)
DURATION OF GOOD VIABILITY: 5 years (Flemion & Parker, 1942)
STRATIFICATION AND SCARIFICATION: Soak seed in sulfuric acid for 30 minutes then warm stratify at 86°F for 120 days then moist chill at 41°F for 180 days (Evans, 1974); Soak seed in sulfuric acid for 30 minutes at 77°F then moist chill at 50°F for 180 days (Babb, 1959); Soak seed in sulfuric acid for 30 minutes then warm stratify at 25°C for 3-4 months then moist chill at 10°C for 4-5 months (Flemion & Parker, 1942)

LABORATORY GERMINATION

TEMPERTURE: Constant at 5-10°C (Flemion & Parker, 1942)
GERMINATIVE CAPACITY: 81% in 30 days (Evans, 1974); 70-74% (Flemion & Parker, 1942)

CULTURAL PRACTICES

PLANTING DEPTH: 1/4" (Evans, 1974)
PLANTING TIME: Fall (Evans, 1974); Fall or spring for germination the second year (Swingle, 1939)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)
NURSERY PLANTING: Warm stratify seed in fall, mulch seedbed with 3/4" sawdust (Evans, 1974); Stems easily rooted in open (Mirov & Kraebel, 1939)

SYMPHORICARPOS OREOPHILUS Gray (Mountain Snowberry)

FAMILY: Caprifoliaceae
LIFEFORM: Native shrub 1-1.5 m tall (Harrington, 1964)
FRUIT: A 2-seeded, berry-like drupe 8-10 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 54,065 (Plummer et al., 1968)
SEED MATURITY: Aug 10-Sep 15 UT (Plummer et al., 1968); Summer (Swingle, 1939)
METHOD OF COLLECTION: Strip or knock fruit into hopper or container (Plummer et al., 1968)
METHOD OF CLEANING: Dybvig with water, dry and fan (Plummer et al., 1968)

PRETREATMENT

METHOD OF STORAGE: Dry (Swingle, 1939)
DURATION OF GOOD VIABILITY: 3 years (Plummer et al., 1968)
STRATIFICATION AND SCARIFICATION: May need to soak in hot water (Stark, 1966)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 32% (Griswald, 1936)

CULTURAL PRACTICES

PLANTING TIME: Sow unstratified seed in fall (Evans, 1974); Spring (Sutton & Johnson, 1974)
EXPOSURE: Sun or shade (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium (Sutton & Johnson, 1974)
SOIL pH: 7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist or dry (Sutton & Johnson, 1974)
ORGANIC MATTER: No (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
NURSERY PLANTING: Stems easily rooted in open (Sutton & Johnson, 1974)

TAMARIX PENTANDRA Pall. (Fivestamen Tamarisk)

SYNONOMY: *Tamarix gallica, Tamarix paryifolia*
FAMILY: Tamaricaceae
LIFEFORM: Introduced shrub or small tree 3-8 m tall (Harrington, 1964)
FRUIT: A capsule 3-4 mm long, seeds minute (Reynolds & Alexander, 1974; Harrington, 1964); Seed 0.45 mm long and 0.17 mm wide (Merkel, 1957)

PROCUREMENT

SEED MATURITY: Apr-Oct AZ (Reynolds & Alexander, 1974); Jun-Nov, best in Aug KA (Merkel, 1957)
METHOD OF COLLECTION: Hand strip into container (Reynolds & Alexander, 1974)
METHOD OF CLEANING: Not recommended (Reynolds & Alexander, 1974)

PRETREATMENT

METHOD OF STORAGE: Store at 40°F (Reynolds & Alexander, 1974); Store at 10°F (Merkel, 1957)
DURATION OF GOOD VIABILITY: Up to 2 years (Reynolds & Alexander, 1974; Horton et al., 1960); 3 months at 2-5°C (Hullett & Tomanek, 1961); 6-17 weeks at room temperature, 1-5 weeks in greenhouse (Horton et al., 1960); 9 months at 10°C (Merkel, 1957)
STRATIFICATION AND SCARIFICATION: None necessary (Reynolds & Alexander, 1974)

LABORATORY GERMINATION

TEMPERATURE: Constant at 70°F (Reynolds & Alexander, 1974)
MOISTURE: Saturated (Hullet & Tomanek, 1961; Horton et al., 1960)
LIGHT: Light not necessary (Horton et al., 1960)
GERMINATIVE ENERGY: 78% in 1 day (Reynolds & Alexander, 1974)
GERMINATIVE CAPACITY: 88% in 6 days (Reynolds & Alexander, 1974); 43-66% (Hullet & Tomanek, 1961); 19.6-32.5% in 6 days (Merkel, 1957)
COMMENTS: Highest germination rate from seed harvested in August and lowest in June (Merkel, 1957)

CULTURAL PRACTICES

PLANTING DEPTH: Best germination at surface, best establishment from 1/4-1/2" (Hullet & Tomanek, 1961)
PLANTING TIME: Spring (Stark, 1966); Anytime in summer when sufficient moisture is available (Hullet & Tomanek, 1961)
EXPOSURE: Sun (Stark, 1966)
SOIL pH: Alkali tolerant (Stark, 1966); Will germinate between pH 2.2 and 10.0, best germination between pH 5.6 to 7.0 (Hullet & Tomanek, 1961)
SOIL SALINITY: Will germinate in 100-10,000 ppm NaCl (Hullet & Tomanek, 1961)
SOIL MOISTURE: Moderately moist to wet, drought tolerant (Stark, 1966); Saturated for germination (Hullet & Tomanek, 1961)
NURSERY PLANTING: Soil must be kept constantly moist during establishment (Reynolds & Alexander, 1974)

TETRADYMIA CANESCENS DC. (Gray Horsebrush)

FAMILY: Asteraceae
LIFEFORM: Native shrub 20-100 cm tall (Harrington, 1964)
FRUIT: A silky hairly achene (Harrington, 1964)

CULTURAL PRACTICES

EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Coarse (Stark, 1966)
SOIL pH: Slight saline-alkaline tolerance (Stark, 1966)
SOIL DEPTH: 30-60" (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
PRECIPITATION: 4-12" (Stark, 1966)
NURSERY PLANTING: Poor germination (Stark, 1966)

TETRADYMIA SPINOSA Hook. & Arn. (Cottonthorn Horsebrush)

FAMILY: Asteraceae
LIFEFORM: Native shrub 50-120 cm tall (Harrington, 1964)
FRUIT: An achene (Harrington, 1964)

PROCUREMENT

SEED MATURITY: Jun-Aug (Swingle, 1939)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 2% (Swingle, 1939)

VACCINIUM CAESPITOSUM Michx. (Dwarf Blueberry)

FAMILY: Ericaceae
LIFEFORM: Native shrub 5-30 cm tall (Harrington, 1964)
FRUIT: A many seeded berry 6-8 mm wide (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 3,700,000-6,000,000--avg 5,300,000 (Crossley, 1974)
SEED MATURITY: Jul-Sep (Crossley, 1974)
METHOD OF COLLECTION: Hand pick or beat bush into container (Crossley, 1974)
METHOD OF CLEANING: Chill to 50°F, macerate in water and float off, dry (Crossley, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry at 41°F (Crossley, 1974)
DURATION OF GOOD VIABILITY: 12 years (Crossley, 1974)
STRATIFICATION AND SCARIFICATION: Not necessary (McLean, 1967); Moist chill 71-112 days (Nichols, 1934)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 96% (Crossley, 1974; McLean, 1967); 33% in 28-169 days (Nichols, 1934)

CULTURAL PRACTICES

EXPOSURE: Shade or sun (Sutton & Johnson, 1974)
SOIL TEXTURE: Medium to coarse on granite soils (Sutton & Johnson, 1974)
SOIL pH: 5.5-7.0 (Sutton & Johnson, 1974)
SOIL DEPTH: Moderate to shallow (Sutton & Johnson, 1974)
SOIL MOISTURE: Moist (Sutton & Johnson, 1974)
ORGANIC MATTER: Yes (Sutton & Johnson, 1974)
DRAINAGE: Well drained (Sutton & Johnson, 1974)
FIELD PLANTING: Blueberries are exacting in their site requirements (Crossley, 1974)

VIBURNUM LENTAGO L. (Nannyberry)

FAMILY: Caprifoliaceae
LIFEFORM: Introduced shrub or small tree to 10 m tall (Harrington, 1964)
FRUIT: A 1-seeded drupe 10-15 mm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 4,320-12,450 (Swingle, 1939)
SEED MATURITY: Sep-Oct (Gill & Pogge, 1974d); Aug-Sep, fall (Swingle, 1939)

PRETREATMENT

METHOD OF STORAGE: Store dry in sealed containers at 2°C (Hartmann & Kester, 1975); Best germination when stored in the pulp at 5°C and then cleaned before planting (Giersbach, 1937b)
DURATION OF GOOD VIABILITY: 1-2 years (Hartmann & Kester, 1975)
STRATIFICATION AND SCARIFICATION: Warm stratify at 20-30°C for 2-9 months then moist chill at 4°C for 2-4 months (Hartmann & Kester, 1975); Stratify 1 year (Swingle, 1939)

CULTURAL PRACTICES

PLANTING TIME: Plant in summer or early fall for next spring germination (Hartmann & Kester, 1975)
EXPOSURE: Sun or partial shade (Gill & Pogge, 1974d)
SOIL pH: Acid tolerant (Gill & Pogge, 1974d)
SOIL MOISTURE: Moist (Gill & Pogge, 1974d)
DRAINAGE: Well drained (Gill & Pogge, 1974d)
GREENHOUSE PLANTING: Reproduces well from cuttings (Swingle, 1939)
FIELD PLANTING: Should use heavy mulch first year, germinates best when spring has a warm period for germination followed by a cold period to force epicotyl development (Giersbach, 1937b)

VITIS RIPARIA Michx. (Riverbank Grape)

SYNONOMY: *Vitis vulpina*
FAMILY: Vitaceae
LIFEFORM: Native woody vine, attaining a length of 10-30 ft (Vines, 1960)
FRUIT: A berry 1/4-1/3" in diameter (Vines, 1960)

PROCUREMENT

SEEDS/LB: 14,500 (Vines, 1960); 7,400-17,210 (Swingle, 1939)
SEED MATURITY: Sep-Oct southwest U.S. (Vines, 1960); Sep or fall (Swingle, 1939)

PRETREATMENT

METHOD OF STORAGE: Dry (Swingle, 1939)
STRATIFICATION AND SCARIFICATION: Moist chill Nov thru Mar (Swingle, 1939)

LABORATORY GERMINATION

GERMINATIVE CAPACTIY: 96% (Swingle, 1939)
COMMENTS: Seed germination is quick and vigorous (Vines, 1960)

CULTURAL PRACTICES

PLANTING TIME: Stratified seed in spring (Swingle, 1939)
GREENHOUSE PLANTING: Reproduces well from cuttings (Vines, 1960; Swingle, 1939)

YUCCA ANGUSTISSIMA Engelm. ex Trel.
(Fineleaf Yucca)

FAMILY: Agavaceae
LIFEFORM: An evergreen shrub 20-40 cm tall (Harrington, 1964)
FRUIT: A dehiscent capsule 3.5-5 cm long (Harrington, 1964)

PROCUREMENT

METHOD OF COLLECTION: Hand pick or strip onto canvas (Alexander & Pond, 1974)
METHOD OF CLEANING: Tumble and screen (Alexander & Pond, 1974)

PRETREATMENT

METHOD OF STORAGE: Sealed container at 70°F (McCleary & Wagner, 1973)
DURATION OF GOOD VIABILITY: 1 year (McCleary & Wagner, 1973)

LABORATORY GERMINATION

TEMPERATURE: Constant at 20°C (McCleary & Wagner, 1973)
GERMINATIVE ENERGY: 14% in 11 days (McCleary & Wagner, 1973)
GERMINATIVE CAPACITY: 28% in 16 days (McCleary & Wagner, 1973): 78% (Swingle, 1939)

YUCCA BACCATA Torr.
(Spanish Bayonet)

FAMILY: Agavaceae
LIFEFORM: Native evergreen shrub 40-75 cm tall (Harrington, 1964)
FRUIT: An indehiscent capsule 15-20 cm long (Harrington, 1964)

PROCUREMENT

METHOD OF COLLECTION: Hand pick or strip onto canvas (Alexander & Pond, 1974)
METHOD OF CLEANING: Tumble & screen (Alexander & Pond, 1974)

PRETREATMENT

METHOD OF STORAGE: Dry at 70°F (Alexander & Pond, 1974); Sealed container at 70°F (McCleary & Wagner, 1973)
DURATION OF GOOD VIABILITY: 1 year (McCleary & Wagner, 1973)

LABORATORY GERMINATION

TEMPERATURE: Constant between 60-70°F (Milstein & Milstein, 1966); Constant at 25°C (McCleary & Wagner, 1973)
LIGHT: Best germination in light (Milstein & Milstein, 1966)
GERMINATIVE ENERGY: 50% in 3 days (McCleary & Wagner, 1973)
GERMINATIVE CAPACITY: Complete in 15-30 days (Milstein & Milstein, 1976); 100% in 7 days (McCleary & Wagner, 1973); 78% (Swingle, 1939)

CULTURAL PRACTICES

EXPOSURE: Sun (Stark, 1966)
SOIL TEXTURE: Medium to coarse (Stark, 1966)
SOIL pH: Found on limestone soils (Stark, 1966)
SOIL MOISTURE: Dry (Stark, 1966)
PRECIPITATION: 6" (Stark, 1966)
NURSERY PLANTING: Grown from seed successfully (Stark, 1966)

YUCCA GLAUCA (Nutt.)
(Great Plains Yucca)

FAMILY: Agavaceae
LIFEFORM: Native evergreen shrub with leaves to 3 ft tall (Vines, 1960)
FRUIT: A dehiscent capsule approx 3 cm long (Harrington, 1964)

PROCUREMENT

SEEDS/LB: 26,000-28,000 (Eddleman, 1977); 22,680 (Alexander & Pond, 1974)
SEED MATURITY: Aug-Sep (Alexander & Pond, 1974)
METHOD OF COLLECTION: Hand pick or strip onto canvas (Alexander & Pond, 1974)
METHOD OF CLEANING: Tumble and screen (Alexander & Pond, 1974)

PRETREATMENT

METHOD OF STORAGE: Store dry at 70°F (Alexander & Pond, 1974); Sealed container at 70°F (McCleary & Wagner, 1973)
DURATION OF GOOD VIABILITY: 1 year (McCleary & Wagner, 1973)
STRATIFICATION AND SCARIFICATION: Moist chill at 4°C for 1-3 months (Eddleman, 1977); Moist chill 1 month (Milstein & Milstein, 1976); Soak in water for 24 hours at 70°F (Alexander & Pond, 1974)

LABORATORY GERMINATION

TEMPERATURE: Constant at 60-70°F (Milstein & Milstein, 1976); Constant at either 82-90°F or 20°C (Alexander & Pond, 1974); Constant at 25°C (McCleary & Wagner, 1973)
LIGHT: Best germination in light (Milstein & Milstein, 1976)

GERMINATIVE ENERGY: 50% in 6-10 days (Eddleman, 1977); 80-90% in 4 days (Alexander & Pond, 1974); 50% in 5.5 days (McCleary & Wagner, 1973)
GERMINATIVE CAPACITY: 83-91% (Eddleman, 1977); Complete in 15-30 days (Milstein & Milstein, 1976); 80% in 20 days (Alexander & Pond, 1974); 100% in 8 days (McCleary & Wagner, 1973); Complete in 4 days (Webber, 1953); 32% (Swingle, 1939)

CULTURAL PRACTICES

PLANTING TIME: Spring (Alexander & Pond, 1974)
SOIL TEXTURE: Coarse (Eddleman, 1977)
GREENHOUSE PLANTING: Only 20% survival from greenhouse planting (Arnott, 1962)
NURSERY PLANTING: Mulch the first fall before frost (Alexander & Pond, 1974)
FIELD PLANTING: In nature reproduction by seed is limited, seedlings grow slowly, seeds may not germinate for one to several years (Webber, 1953)

YUCCA HARRIMANIAE Trel.
(Harriman Yucca)

FAMILY: Asteraceae
LIFEFORM: Native evergreen shrub with leaves 4-18" long (Vines, 1960)
FRUIT: A dehiscent capsule 4-5.7 cm long (Harrington, 1964)

LABORATORY GERMINATION

GERMINATIVE CAPACITY: 58% (Swingle, 1939)

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APPENDIX I

Colorado shrub species that have been evaluated by the USDA Soil Conservation Service Plant Materials Centers

Species	State[1]									
	AR	CA	CO	ID	KA	MT	NM	OR	TX	WA
cer glabrum			X	X						
melanchier alnifolia			X		X		X			
. utahensis			X	X						
morpha canescens					X					
. fruticosa					X	X	X		X	
rctostaphylos patula		X	X							
. uva-ursi		X	X							
rtemisia arbuscula nova		X	X							
. cana		X								
. frigida			X	X		X				
nova			X	X						
spinescens		X		X						
tridentata		X	X							
riplex canescens	X	X	X	X		X	X		X	
confertifolia	X	X	X	X			X			
A corrugata			X							
A cuneata			X				X			
A gardneri		X								
A nuttallii		X	X	X		X	X			
A obovata							X			
Be beris fendleri			X							
B repens			X							
Ce nothus fendleri									X	
.ovatua					X					
.velutinus		X	X	X						
e atoides lanata			X	X		X				
e ocarpus intricatus			X							
. edifolius		X	X	X						
. ontanus			X	X		X	X		X	
h sothamnus depressus			X				X			
. auseosus		X	X				X			
. arryi			X							
. iscidiflorus		X	X	X						
le atis ligusticifolia			X	X			X			
lo gyne ramosissima		X								
or us stolonifera		X	X		X		X			
ow ia stansburiana		X	X	X			X			
a geus spp.			X							
a gnus umbellata		X	X		X	X	X		X	

Appendix I.--Continued

Species	State[1]									
	AR	CA	CO	ID	KA	MT	NM	OR	TX	WA
Ephedra torreyana			X							
E. viridis		X		X			X			
Eurotia lanata	X	X	X				X			
Fallugia paradoxa	X		X				X			
Fendlera rupicola			X				X			
Forestiera neomexicana		X	X		X	X	X		X	
Grayia spinosa		X	X							
Haplopappus spp.			X							
Holodiscus dumosus			X							
Jamesia americana			X							
Juniperus communis			X		X					
J. horizontalis glauca					X					
Kochia americana		X								
Larrea tridentata	X	X								
Lonicera involucrata			X		X				X	
L. utahensis			X							
Lycium halimifolium						X			X	
Mahonia fremontii			X							
M. repens			X							
Menodora scabra	X									
Nolina microcarpa			X				X			
Parthenocissus vitacea			X							
Penstemon ambiguus			X							
Peraphyllum ramosissimum			X							
Philadelphus microphyllus			X							
Physocarpus monogynus			X							
Potentilla fruticosa			X		X		X			
Prunus besseyi					X					
P. virginiana			X	X		X	X			
Purshia tridentata		X	X	X			X			
Quercus gambelii			X				X			
Rhamnus smithii			X							
Rhus glabra			X	X	X	X	X		X	
R. trilobata		X	X	X	X	X	X		X	
Ribes americanum			X							
R. aureum			X	X						
R. cereum			X				X			
R. leptanthum							X			
R. montigenum			X							
Rosa arkansana					X					
R. multiflora					X					
R. nutkana		X	X							
R. woodsii		X	X				X			
Rubus deliciosus			X							
R. parviflorus		X	X		X					

ppendix I.--Continued

Species	AR	CA	CO	ID	KA	MT	NM	OR	TX	WA
alix interior					X					
. lasiandra		X								
. purpurea nana						X				
ambucus canadensis									X	
. coerulea		X					X			
. pubens			X							
. racemosa					X		X			
apindus drummondii									X	
arcobatus vermiculatus		X	X							
hepherdia argentea			X		X	X	X			
orbus scopulina			X							
ymphoricarpos albus			X				X			
. longiflorus		X								
occidentalis			X							
orbiculatus					X				X	
oreophilus			X				X			
vaccinoides		X								
tradymia canescens			X							
cca angustissima						X				
baccata		X	X							
glauca					X		X			
harrimaniae			X							

---

[1] STATE: AR = Arizona; CA = California; CO = Colorado; ID = Idaho; KA = Kansas; MT = Montana; = New Mexico; OR = Oregon; TX = Texas; WA = Washington.

APPENDIX II

Western USDA Soil Conservation Service Plant Materials Centers

---

3241 Romero Road
Tucson, Ariz. 85705

P.O. Box 68
Lockeford, Calif. 95236

P.O. Box 448
Meeker, Colo. 81641

Box AA
Aberdeen, Idaho 83210

Route 2, Box 314
Manhattan, Kans. 66509

Route 1, Box 81
Bridger, Mont. 59014

1036 Miller Street, S.W.
Los Lunas, N. M. 87031

3420 N.E. Granger Avenue
Corvallis, Oreg. 97330

Box 648
Temple, Texas 76501

257 Johnson Hall
Washington State University
Pullman, Wash. 99163

APPENDIX III

Commercial suppliers of Colorado shrubs

Supplier	Supplier's number
plewood Seed Co. 3 Parfet Street kewood, Colo. 80215	1
borland Nursery 465 Colorado State Hwy. lliken, Colo. 80543	2
kansas Valley Seeds, Inc. O. Box 270 cky Ford, Colo. 81067	3
arkdale Nursery lbank, S. D. 57252	4
ert Enterprises). Box 23 ristown, Ariz. 85342	5
's Nursery and Seed ldon, N. D. 58068	6
verland Garden West 120 Avenue mfield, Colo. 80020	7
E. Goble and Sons Seed Co. Box 175 ison, Utah 84634	8
sland Resources, Inc. .C Box 1596 Fe, N. M. 87501	9
Gardens South Broadway eton, Colo. 80121	10
and Nursery West 20 Street ey, Colo. 80631	11
r Nursery 2, Box 95 , Mont. 59859	12
n-Oakes Nurseries 01 ck, N. D. 58501	13
igh Seed Co. ox 1988 Junction, Colo. 81501	14

Appendix III.--Continued

Supplier	Supplier's number
Morgan Nursery 2200 Reservoir Road Greeley, Colo. 80631	15
Mountain Meadows Nursery 5050 Coal Mine Road Littleton, Colo. 80123	16
Native Plants P.O. Box 15526 Salt Lake City, Utah 84115	17
Northplan Seed Producers P.O. Box 9107 Moscow, Idaho 83843	18
Nuzum Nurseries 96 Arapahoe Avenue Boulevard Denver, Colo.	19
Plumfield Nurseries, Inc. P.O. Box 410 2105 North Nye Avenue Fremont, Nebr. 68025	20
Powder River Seed Co. Box 673 Broadus, Mont. 59317	21
Rocky Mountain Natives Wholesale Nursery 2221 North Whitcomb Fort Collins, Colo. 80521	22
Sharp Brothers Seed Co. Healy, Kans. 67850	23
J. H. Skinner and Co. Nursery Box 8068 1402 L. Silver Lake Road Topeka, Kans. 66608	24
South Denver Evergreen Nursery 1534 South Broadway Denver, Colo. 80210	25
Valley Seed Co. P.O. Box 1110 Phoenix, Ariz. 85001	26
Western Evergreen 14201 West 44 Avenue Golden, Colo. 80401	27
Woodman Brothers 1801 West Belleview Littleton, Colo. 80120	28

APPENDIX IV

Commercial suppliers of Colorado shrubs, seeds, seedlings, or transplants

Species	Seed	Seedling^2	Transplant^3
er glabrum	12,16,18,25,27	12	16,17,22,25,27
elanchier alnifolia	8,12,16,18,23,27	12,20	16,17,22,27
elanchier utahensis	8		17,22
orpha canescens	16,18,21,27		16,22,27
orpha fruticosa	12		
ctostaphyllos patula	18		
ctostaphyllos uva-ursi	10,12,18,25	12	22
temisia abrotanum	8		17
temisia arbuscula nova (A. nova)	8,23		
emisia cana	21		
emisia filifolia			17,27
emisia frigida	16		17
emisia tridentata	8,12,18,21,23		17,22,27
emisia vaseyana vaseyana (A. tridentata vaseyana)	8		
iplex canescens	3,8,9,12,14, 18,21,23,25		17,22
iplex confertifolia	8,18,21		
iplex cuneata			17
iplex gardneri	8		22
plex nuttallii	12,21		
othus martinii	8		22
othus velutinus	12		22
toides lanata (urotia lanata)	8,21,23		22
ocarpus ledifolius	8,16,23		22
ocarpus montanus	7,8,10,16,23,27		7,10,16,17,22,27
sothamnus lanceolatus (. viscidiflorus lanceolatus)	21		
sothamnus nauseosus	1,8,12,18,21,23		17,22
sothamnus stenophyllus (viscidiflorus stenophyllus)	8		
othamnus viscidiflorus	8		
tis ligusticifolia			17
ea arborescens	23		
s stolonifera	8,12,18	12,13,20,24	17,22
ia mexicana stansburiana	8,23		17,22
gnus angustifolia	8,12	4,13,24	17,22
gnus commutata	12	13	
ra viridis	8,12,18,23		17,22
ia paradoxa	16,27		16,22,27
iera neomexicana	27		17,27
a americana			22
rus communis		12	17
ra involucrata	8		
a repens (beris repens)	7,8,10,12,16, 18,19		17,22,27
a erinacea	5		

(continued)

Appendix IV.--Continued

Species	Seed	Seedling[2]	Transplant[3]
Opuntia imbricata (*Cylindropuntia imbricata*)	5		
Opuntia phaeacantha	5		
Peraphyllum ramosissimum	8,23		17
Physocarpus malvaceus			22
Physocarpus monogynus	16		
Potentilla fruticosa		24	
Prunus americana	8,12	4,6,13,20,24	6,27
Prunus besseyi	2,11,12,15	4,6,20,24	6,27
Prunus virginiana melanocarpa	8,18	13,20	4,16,17,27
Purshia tridentata	8,12,18,23,27		17,22,27
Quercus gambellii	7,8		16,17,19,22,27
Rhamnus cathartica		12	
Rhus glabra cismontana	12,18	24	16,17,22,27
Rhus trilobata	8,12,16,18,21,25,27		4,16,17,25,2 27
Ribes aureum	8,12	12,13,20	16,17,22
Ribes inerme	28		28
Ribes leptanthum	28		28
Rosa nutkana	18		
Rosa woodsii	1,8,18		17,22
Rubus parviflorus			22
Salix purpurea lambertiana	20		
Sambucus coerulea	8,18		17
Sambucus racemosa pubens	21,27		22,27
Sarcobatus vermiculatus	8		
Shepherdia argentia	2,12	13,20	4,11,15,17, 28
Sorbus scopulina	12,18		17
Symphoricarpos albus	12,18,27	12	22,27
Yucca baccata	1		
Yucca glauca	1,12,21	12,13	22

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[1] Suppliers are identified by number shown in appendix III.
[2] Seedling--bare root stock.
[3] Transplant--tubeling or potted plant.

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1980. Growing Colorado plants from seed: a state of the art. Volume I: shrubs. USDA For. Serv. Gen. Tech. Rep. INT-103, 80 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Information included relates to seed procurement, pretreatment, laboratory germination, and culture of 127 Colorado shrub species. Also included are 234 literature citations, a list of the Colorado shrub species that have been evaluated by USDA Soil Conservation Plant Materials Centers, addresses of plant material centers in the western United States, a list of the commercial suppliers of Colorado shrub, seed, seedlings, and transplants, and a list of the addresses of commercial suppliers of Colorado shrubs.

KEYWORDS: germination, propagation, shrubs, Colorado seeds, field planting

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The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

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POINT AND LINE-INTERSECT SAMPLING IN PINYON-JUNIPER WOODLANDS

RICHARD O. MEEUWIG AND

JERRY D. BUDY

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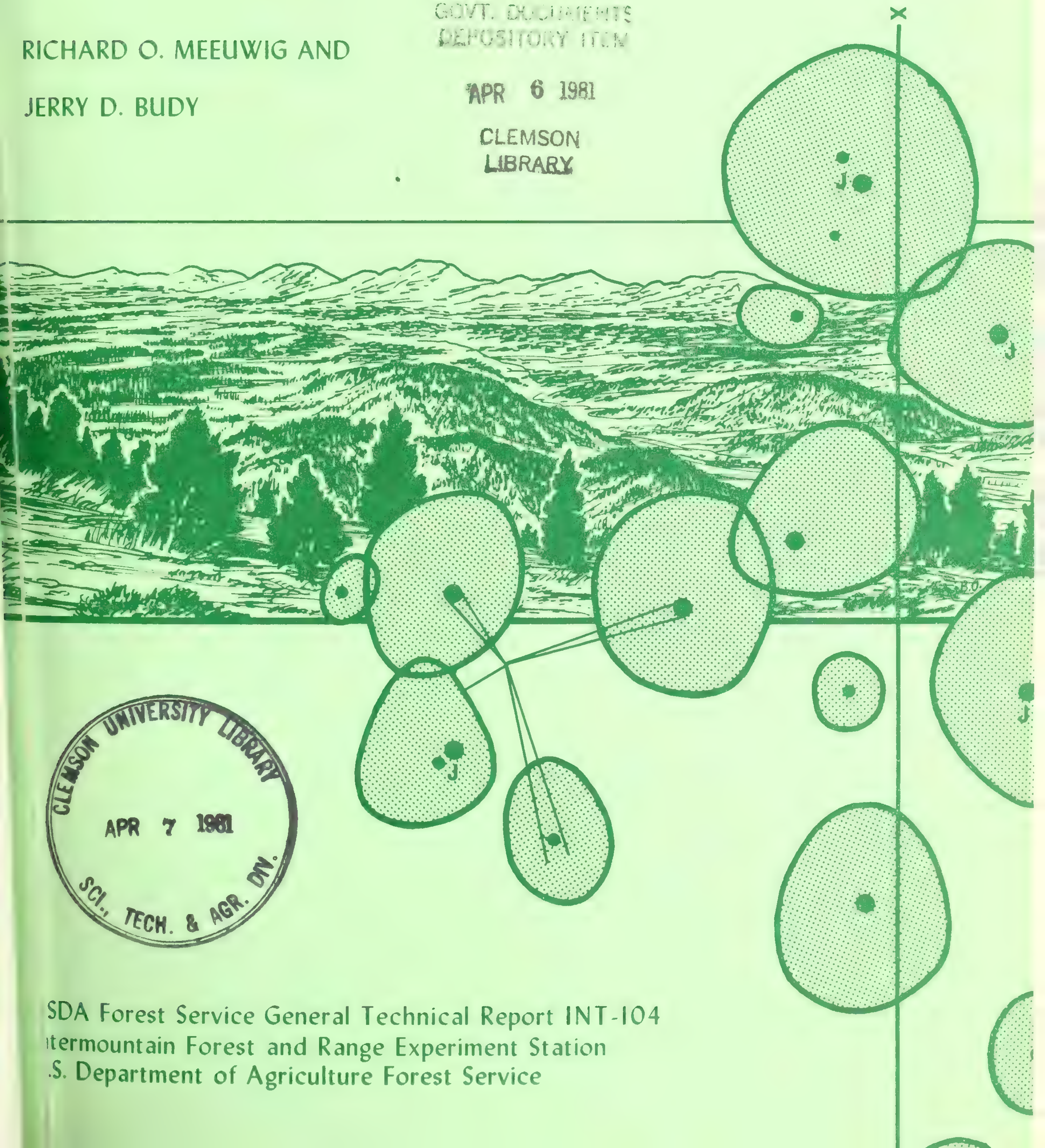

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RESEARCH SUMMARY

Two probability proportional to size (p.p.s.) sampling methods have been adapted for use in pinyon-juniper woodlands. Procedures are described for estimating biomass, stand basal area, canopy cover, tree density, and growth rates using either point sampling or line-intersect sampling. Both sampling methods are supported by regression equations for estimating aboveground biomass, cordwood, slash, fine fuels, and foliage of singleleaf pinyon and Utah juniper. Regression equations for predicting decadal growth rates in terms of stand basal area, aboveground biomass, and cordwood are also presented. These procedures can be modified for use with other woodland species.

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February 19

POINT AND LINE-INTERSECT SAMPLING IN PINYON-JUNIPER WOODLANDS

Richard O. Meeuwig and Jerry D. Budy

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
U.S. Department of Agriculture
Forest Service
Ogden, Utah 84401

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INTRODUCTION

Although pinyon-juniper woodlands cover vast areas in the western United States, little attention has been given to assessing their wood resources until recently. Volume tables have been developed for pinyon and juniper species in New Mexico and Arizona by Howell (1937, 1940) and by Howell and Lexen (1939), in northern New Mexico and south-central Colorado by Estola (1979), and in northern New Mexico by Clendenen (1979). Moessner (1962) developed an aerial volume table for pinyon and juniper in Utah. Reveal (1944) reported volume characteristics of singleleaf pinyon and Utah juniper in western Nevada.

A comprehensive study of biomass characteristics of singleleaf pinyon *(Pinus monophylla)* and Utah juniper *(Juniperus osteosperma)* has been completed recently (Budy and others 1979). Some preliminary results of this study were reported in notes on line-intersect sampling (Meeuwig and others 1978) and on aerial sampling (Meeuwig and others 1979). These notes introduced the concept of probability proportional to size (p.p.s.) sampling in pinyon-juniper woodlands. This report elaborates on the concept, explaining in detail how point sampling and line-intersect sampling can be used to determine biomass, growth rates, and other characteristics of singleleaf pinyon-Utah juniper stands.

The angle method, originated by Bitterlich (1947) to estimate stand basal area, was extended to timber cruising by Grosenbaugh (1952). It proved to be an efficient and relatively simple method for forest inventory. Standard procedures are described in forest mensuration texts such as that by Husch and others (1972). The method is not feasible in many pinyon-juniper stands because of irregular stems, multiple stems, and stems concealed by foliage. Juniper trees do not generally appear amenable to angle cruising, but the method can be applied successfully to pinyon trees in many cases if stump height instead of breast height is used as the sighting level.

The point sampling procedure described in this paper uses two different, but related, methods for selecting sample trees. The Bitterlich method is used for pinyons, and a method based on crown area is used for juniper. A juniper tree would be included in the sample if the distance from the sample point to its stem center is no greater than its average crown diameter. Thus, pinyon is sampled in proportion to basal area and juniper is sampled in proportion to crown area.

In stands where the Bitterlich method cannot be applied satisfactorily, line-intersect sampling can be used instead. Line-intersect sampling was conceived by Warren and Olsen (1964) to assess logging waste in New Zealand and Brown (1971) adapted it to sample forest fuels. Fries (1973) presented a generalized theory on line-intersect sampling. Meeuwig and others (1978) developed a pinyon-juniper cordwood cruising method using line-intersect sampling. The method is simple; trees are included in the sample if any portion of their crown intersects a ransect line. This method samples in proportion to crown diameter and, therefore, is less fficient than point sampling, but it is usually easier to use in pinyon-juniper woodlands.

Two different proportional sampling methods have been described: point and line intersect. hich method to use depends primarily on the characteristics of the stand to be sampled. If he stand contains a high proportion of juniper or if the pinyon stems are irregular or difficult o see at stump height, the line-intersect method is the proper choice. But it is difficult to se the line-intersect method in some older stands because the tree crowns are sparse and rregular and reach their maximum spread at heights well above the ground. Here, the point ethod is the clear choice.

The choice is more difficult in situations between these extremes. The point method is enerally more efficient because it samples in proportion to basal area or crown area while he line-intersect method samples in proportion to crown diameter. Therefore, the point ethod should be used whenever practical, even in those situations where some clearing of e lower branches is occasionally needed to provide a satisfactory view of the stem, or where may sometimes be necessary to tape stem diameter and distance to determine whether a tree ould be tallied or not. In extensive stratified surveys, some stands could be sampled by ne intersect while others are sampled by the point method.

At first glance, this paper may seem to be a complicated series of equations and tables and contains elements that may be of little interest to most woodland managers at present. But as utilization and management of pinyon-juniper woodlands intensifies, these procedures will become important aids to effective management of the woodlands.

The regression equations are more complex than most published biomass equations or volume equations. This complexity is caused by the wide variation in the growth form of the species involved. Simpler equations could be developed but would be less precise and not apply to the more extreme growth forms. Although some of the terms in the regression equations are complicated, particularly in the growth equations, the input variables are not. For pinyon biomass, the only input variables are stump diameter, height, and average crown diameter. For juniper biomass, the only input variables are average crown diameter, diameter breast height, and number of stems at breast height. The only additional input variable for the growth equations is decadal radial wood growth (the width of the 10 outermost complete annual rings).

POINT SAMPLING

This procedure is designed for predominantly pinyon stands in which the pinyon stems are sufficiently well-formed and visible at stump height to allow the use of an angle gage. Sinc Utah juniper stems rarely meet these criteria, an alternative point sampling method based on crown area is used to sample the occasional juniper.

A series of sample points is laid out on the area to be inventoried according to some prearranged system, such as a grid of equally spaced points or as randomly located points. The sampling design depends on the nature of the stand being sampled and the preferences of the designer. Methods for determining the number of sample points required for achieving a given level of accuracy are described in appendix A.

At each sampling point, the sample pinyon trees are selected with an angle gage sighted at stump height (15 cm or 6 inches). The stick-gage described by Meeuwig (1977) is recommended for this purpose because it affords a clearer view than a prism and is easily adjuste for inclined line-of-sight. Basal area factors of 10 m^2/ha or 40 ft^2/acre are about right f well-stocked stands. Smaller basal area factors (*Bf*) should be used in more open stands, because it is desirable to obtain at least one sample tree at each sampling point.

On some borderline trees with irregular stems at stump height, it may be necessary to tape the stump diameter (*Ds*) and the horizontal distance (*L*) from the sampling point to the stem center. A tree would be tallied if

$\frac{L}{Ds}$ is no greater than $\frac{50}{\sqrt{Bf}}$ in metric units or

no greater than $\frac{33}{\sqrt{Bf/10}}$ in U.S. units.

With a basal area factor of 10 m^2/ha, a tree would be tallied if *L* is no greater than 15.8·*I*. With a basal area factor of 40 ft^2/acre, a tree would be tallied if *L* is no greater than 16.5·*Ds*.

A juniper tree would be sampled if the distance from the sampling point to the nearest portion of its crown is no greater than one-half its average crown diameter. This criterio is essentially equivalent to requiring that the stem center be within one crown diameter of the sampling point, but it is easier to apply and overcomes the problems caused by multiple stems. It would be simpler to sample only those junipers whose crowns are over the samplin point, but this would result in the junipers being undersampled in relation to the pinyons. The sampling intensity is increased fourfold by the selection criterion given above and brought to a level comparable to that of pinyon selected by a 10 m^2/ha or 40 ft^2/acre angle gage.

Estimates of biomass per unit area, stand basal area, growth rates, and other stand characteristics can be obtained at each sampling point. Estimated pinyon biomass per unit area $(\frac{M}{A})$ at a sampling point is calculated by:

$$\frac{M}{A} = Bf \sum^{n} \frac{M_i}{B_i}$$

In metric units, $\frac{M}{A}$ is in kg/ha, Bf is the basal area factor in m^2/ha, M_i is the mass (kg) of each sample pinyon tree, and B_i is the basal area (m^2) of that sample tree at stump height. In U.S. units, $\frac{M}{A}$ is in pounds per acre, Bf is in square feet per acre, M_i is in pounds, and B_i is in square feet.

Estimated juniper biomass per unit area at a sampling point is calculated by:

$$\frac{M}{A} = \frac{k}{4} \sum^{n} \frac{M_i}{Ca_i}$$

Ca_i is the crown area (m^2 or ft^2) of each sample tree. The factor k is 10 000 m^2/ha or 43,560 ft^2/acre, needed to convert the estimate to a kilogram per hectare or a pounds per acre basis. Division by 4 is necessary because the probability of selection of any particular juniper is equivalent to four times its crown area.

The basic strategy in the use of the two preceding equations is to estimate, by regression equations or tables, the biomass per unit basal area $(\frac{M}{B})_i$ of each sample pinyon and the biomass er unit crown area $(\frac{M}{Ca})_i$ of each sample juniper. The sums of the estimates for each of the wo species are used in the two equations to obtain estimated biomass per unit land area at ach sampling point.

Using the data of the 72 singleleaf pinyons and 33 Utah junipers from the biomass study eported by Budy and others (1979), multiple regression equations were developed for estimatng the ratios of mass to basal area $(\frac{M}{B})$ of pinyon and of mass to crown area $(\frac{M}{Ca})$ of juniper or the following tree components:

1. Cordwood: ovendry mass of wood (with bark) larger than 76-mm (3-inch) diameter tside bark.

2. Slash: ovendry mass of all material smaller than 76-mm (3-inch) diameter outside rk.

3. Aboveground biomass: cordwood and slash.

4. Foliage: ovendry mass of needles or scales.

5. Fine fuels: ovendry mass of foliage plus twigs smaller than 6-mm (¼-inch) diameter outside bark.

The equations were developed through the use of a regression screen program designed to minimize the standard deviation from regression (SDR) with as few variables as practical. The pinyon equations are presented in metric units in table 1 and in U.S. units in table 2. The juniper equations are presented in table 3 (metric) and table 4 (U.S.). The coefficient of variation from regression (CVR%) is the standard deviation from regression expressed as a percentage of the mean (Draper and Smith 1960).

Stem diameter of pinyon is measured at 15 cm (6 inches) above average ground level because it is usually easier to measure there and because it is a better predictor of biomass than diameter at breast height or at ground level. Forking of the main stem, which complicates diameter measurements, generally occurs above 15 cm.

Table 1.--*Regression equations for estimating mass per square meter of basal area of pinyon trees. The dependent variable (Y) is component mass divided by basal area* (kg/m^2)*. Ds is stem diameter (cm) outside bark at stump height (15 cm). H is tree height (m) and C is average crown diameter (m)*

Component	Regression equation	$\bar{Y}$	SDR	CVR	R^2
		- - kg/m²	*- -*	*Percent*	
Total	$\hat{Y} = 310.5H + 616.7C - 75.87Ds - 11511 \frac{1}{Ds} + 1099$	3 123	438	14.0	0.846
Cordwood	$\hat{Y} = 266.3H + 89.7C - 836$	1 337	250	18.7	.907
Slash	$\hat{Y} = 16201\frac{C}{Ds} - 29929\frac{1}{Ds} - 17.01Ds + 1064$	1 786	358	20.0	.668
Fine fuels	$\hat{Y} = 10235\frac{C}{Ds} - 46971\frac{C}{Ds^2} - 6.98Ds - 169$	871	233	26.8	.538
Foliage	$\hat{Y} = 4416\frac{C}{Ds} - 172$	506	161	31.9	.402

Table 2.--*Regression equations for estimating weight per square foot of basal area of pinyon trees. The dependent variable (Y) is component weight divided by basal area* (lb/ft^2)*. D is stem diameter (inches) outside bark at stump height (6 inches). H is tree height in feet and C is average crown diameter in feet*

Component	Regression equation	$\bar{Y}$	SDR	CVR	R^2
		- - Lb/ft²	*- -*	*Percent*	
Total	$\hat{Y} = 19.38H + 38.50C - 39.47Ds - 928.2\frac{1}{Ds} + 225.1$	640	90	14.0	0.846
Cordwood	$\hat{Y} = 16.62H + 5.60C - 171.2$	274	51	18.7	.907
Slash	$\hat{Y} = 398.3\frac{C}{Ds} - 2413\frac{1}{Ds} - 8.85Ds + 217.9$	366	73	20.0	.668
Fine fuels	$\hat{Y} = 251.5\frac{C}{Ds} - 454.5\frac{C}{Ds^2} - 3.63Ds - 34.6$	178	48	26.8	.538
Foliage	$\hat{Y} = 108.5\frac{C}{Ds} - 35.2$	104	33	31.9	.402

Table 3.--*Regression equations for estimating mass per square meter of crown area of juniper trees. The dependent variable (Y) is component mass divided by crown area (kg/m*^{2}*).* Db *is stem diameter (cm) outside bark at breast height (137 cm).* C *is average crown diameter in meters and* Sb *is the number of stems larger than 7.6-cm diameter at breast height*

Component	Regression equation	$\bar{Y}$	SDR	CVR	R^2
		- - *kg/m*^{2}	- -	*Percent*	
Total	$\hat{Y} = 1.662\frac{Db}{C} + 1.900C - 0.1339C^2 - 3.338$	9.32	1.94	20.9	0.669
Cordwood	$\hat{Y} = 0.6788\frac{Db}{C} + 0.002054Db^2 + 2.355Sb^{-\frac{1}{2}} - 3.195$	2.87	0.60	20.7	.893
Slash	$\hat{Y} = 0.7771\frac{Db}{C} + 1.925C - 0.1800C^2 - 1.393$	6.46	1.54	23.9	.436
Fine fuels	$\hat{Y} = 0.4573\frac{Db}{C} + 0.5734C - 0.0706C^2 + 0.480$	3.48	0.82	23.5	.387
Foliage	$\hat{Y} = 0.3682\frac{Db}{C} + 0.4280C - 0.0544C^2 + 0.443$	2.76	.64	23.2	.397

able 4.--*Regression equations for estimating weight per square foot of crown area of juniper trees. The dependent variable (Y) is component weight divided by crown area (lb/ft*^{2}*).* Db *is stem diameter (inches) outside bark at breast height (4.5 ft).* C *is average crown diameter in feet and* Sb *is the number of stems larger than 3 inches diameter at breast height*

Component	Regression equation	$\bar{Y}$	SDR	CVR	R^2
		- - *Lb/ft*^{2}	- -	*Percent*	
Total	$\hat{Y} = 2.836\frac{Db}{C} + 0.1186C - 0.002548C^2 - 0.684$	1.909	0.397	20.9	0.669
Cordwood	$\hat{Y} = 1.158\frac{Db}{C} + 0.002714Db^2 + 0.4823Sb^{-\frac{1}{2}} - 0.654$	0.587	.122	20.7	.893
Slash	$\hat{Y} = 1.326\frac{Db}{C} + 0.1202C - 0.003425C^2 - 0.285$	1.322	.316	23.9	.436
Fine Fuels	$\hat{Y} = 0.780\frac{Db}{C} + 0.0358C - 0.001343C^2 + 0.0983$	.712	.168	23.5	.387
Foliage	$\hat{Y} = 0.628\frac{Db}{C} + 0.0267C - 0.001035C^2 + 0.0907$	.566	.131	23.2	.397

Stem diameter of Utah juniper is often difficult to measure at any height. Main stem forking is common, especially near ground level. On Utah juniper, diameter at breast height (1.37 m or 4.5 ft) is easier to measure and is a better predictor of biomass than diameter at stump height or ground level.

It is necessary on multistem trees to measure all stems larger than 76-mm (3-inch) diameter and calculate an equivalent diameter. Equivalent diameter is the diameter of a circle having the same area as the combined cross-sectional area of the stems of the multistemmed tree. It is the square root of the sum of the squared diameters of the individual stems:

$$\text{Equivalent diameter} = \sqrt{D_1^2 + D_2^2 + \ldots D^2{}_n}$$

For pinyon trees that are forked at stump height, equivalent diameter is calculated not only for use with the regression equations and tables but also may be needed to determine whether or not borderline trees should be tallied. Line-intersect sampling should be used instead of the point method if the stand has an appreciable proportion of pinyons that fork a stump height.

Average crown diameter (C) is the geometric mean of the maximum crown diameter (Cx) and the crown diameter (Cy) perpendicular to the axis of the maximum crown diameter.

$$C = \sqrt{Cx \cdot Cy}$$

Crown area (Ca) is calculated by:

$$Ca = \frac{\pi}{4} \cdot Cx \cdot Cy = \frac{\pi}{4} C^2$$

The use of the regression equations is demonstrated in the following sections. The examples are given in U.S. units, but the general procedures would be the same in metric unis. In fact, the calculations are often simplified using metric units.

Cordwood and Slash

Table 5 is similar to a volume table, providing estimates of pounds of pinyon cordwood er square foot of stump basal area for various tree heights and crown diameters. It was calculated from the cordwood equation in table 2. Table 6, based on the slash equation in table 2, provides estimates of pinyon slash for various stump diameters and crown diameters.

Estimates of juniper cordwood and slash (in pounds per square foot of crown area) for various crown diameters and stem diameters breast height are in tables 7 and 8. These tabls are based on equations in table 4. The estimates in table 7 are for single stem junipers. For multiple stem junipers, count the number of stems 3 inches or more in diameter at brea height and reduce the estimate from table 7 as follows:

No. stems	Subtract
2	0.14 lb/ft^2
3	.20
4	.24
5	.27
6	.29
7	.30
8	.31
9	.32
10	.33
11	.34
12	.34

Table 5.--*Pinyon cordwood in pounds per square foot of stump basal area*

Height	Crown diameter (feet)														
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
Feet							*Pounds per square foot*								
12	73	84	95	107	118	129	140								
13	90	101	112	123	134	146	157								
14	106	117	129	140	151	162	173	185							
15	123	134	145	156	168	179	190	201							
16	140	151	162	173	184	196	207	218	229						
17	156	167	179	190	201	212	223	235	246						
18	173	184	195	206	218	229	240	251	262	274					
19	189	201	212	223	234	245	257	268	279	290					
20	206	217	228	240	251	262	273	284	296	307	318				
21	223	234	245	256	267	279	290	301	312	323	335				
22	239	250	262	273	284	295	306	318	329	340	351	362			
23	256	267	278	289	301	312	323	334	345	357	368	379			
24	272	284	295	306	317	328	340	351	362	373	384	396	407		
25	289	300	312	323	334	345	356	367	379	390	401	412	423		
26	306	317	328	339	351	362	373	384	395	407	418	429	440	451	463
27	322	334	345	356	367	378	390	401	412	423	434	446	457	468	479
28	339	350	361	373	384	395	406	417	429	440	451	462	473	485	496
29		367	378	389	400	412	423	434	445	456	468	479	490	501	512
30		383	395	406	417	428	439	451	462	473	484	495	507	518	529
31			411	422	434	445	456	467	478	490	501	512	523	534	546
32			428	439	450	461	473	484	495	506	517	529	540	551	562
33				456	467	478	489	500	512	523	534	545	556	568	579
34				472	483	495	506	517	528	539	551	562	573	584	595
35					500	511	522	534	545	556	567	578	590	601	612
36					517	528	539	550	562	573	584	595	606	618	629
37						545	556	567	578	589	601	612	623	634	645
38						561	572	584	595	606	617	628	640	651	662
39						578	589	600	611	623	634	645	656	667	679
40						594	606	617	628	639	650	662	673	684	695

Table 6.--*Pinyon slash in pounds per square foot of stump basal area*

Stump diameter	Crown diameter (feet)														
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
Inches							*Pounds per square foot*								
6	294	426	559	692	825	957									
7	266	380	494	608	722	835									
8	244	343	443	542	642	742	841								
9	224	313	401	490	578	667	755								
10	207	286	366	446	525	605	685	764							
11	191	263	336	408	480	553	625	698							
12	176	243	309	375	442	508	574	641	707						
13	162	224	285	346	407	469	530	591	652						
14	149	206	263	320	377	434	491	547	604	661					
15	137	190	243	296	349	402	455	508	562	615					
16	125	174	224	274	324	374	423	473	523	573	622				
17	113	160	207	254	300	347	394	441	488	535	581				
18	102	146	190	234	279	323	367	411	456	500	544	588			
19	91	132	174	216	258	300	342	384	426	468	510	552			
20		119	159	199	239	279	319	358	398	438	478	518	557		
21		107	145	183	221	259	296	334	372	410	448	486	524		
22			131	167	203	239	276	312	348	384	420	457	493	529	565
23			117	152	187	221	256	290	325	360	394	429	464	498	533
24				137	171	204	237	270	303	336	370	403	436	469	502
25				123	155	187	219	251	283	314	346	378	410	442	474
26					140	171	201	232	263	293	324	355	385	416	446
27					126	155	185	214	244	273	303	332	362	391	421
28						140	168	197	225	254	282	311	339	368	396
29						125	153	180	208	235	263	290	318	345	372
30							138	164	191	217	244	270	297	323	350
31							123	148	174	200	225	251	277	303	328
32								133	158	183	208	233	258	282	307
33								118	142	167	191	215	239	263	287
34									127	151	174	197	221	244	268
35									112	135	158	181	203	226	249
36										120	142	164	186	208	231

Table 7.--*Juniper cordwood in pounds per square foot of tree crown area*

D.b.h.	Crown diameter (feet)												
	8	10	12	14	16	18	20	22	24	26	28	30	32
Inches	*Pounds per square foot*												
4	0.45	0.33	0.26	0.20	0.16								
5	.62	.48	.38	.31	.26	0.22							
6	.79	.62	.50	.42	.36	.31	0.27						
7	.97	.77	.64	.54	.47	.41	.37						
8	1.16	.93	.77	.66	.58	.52	.47	0.42					
9	1.35	1.09	.92	.79	.70	.63	.57	.52	0.48				
10	1.55	1.26	1.06	.93	.82	.74	.68	.63	.58	0.54			
11	1.75	1.43	1.22	1.07	.95	.86	.79	.74	.69	.65			
12	1.96	1.61	1.38	1.21	1.09	.99	.91	.85	.80	.75	0.72		
13		1.79	1.54	1.36	1.23	1.12	1.04	.97	.91	.87	.82		
14		1.98	1.71	1.52	1.37	1.26	1.17	1.10	1.04	.98	.94	0.90	
15			1.89	1.68	1.52	1.40	1.31	1.23	1.16	1.11	1.06	1.02	
16			2.07	1.85	1.68	1.55	1.45	1.37	1.30	1.24	1.18	1.14	1.10
17				2.02	1.84	1.71	1.60	1.51	1.43	1.37	1.32	1.27	1.23
18				2.20	2.01	1.87	1.75	1.66	1.58	1.51	1.45	1.40	1.36
19					2.18	2.03	1.91	1.81	1.72	1.65	1.59	1.54	1.50
20					2.36	2.20	2.07	1.97	1.88	1.80	1.74	1.69	1.64
21						2.38	2.24	2.13	2.04	1.96	1.89	1.84	1.79
22						2.56	2.42	2.30	2.20	2.12	2.05	1.99	1.94
23							2.60	2.47	2.37	2.29	2.22	2.15	2.10
24							2.78	2.66	2.55	2.46	2.38	2.32	2.26

Table 8.--*Juniper slash in pounds per square of tree crown area*

D.b.h.	Crown diameter (feet)												
	8	10	12	14	16	18	20	22	24	26	28	30	32
Inches	*Pounds per square foot*												
4	1.12	1.10	1.11	1.09									
5	1.29	1.24	1.22	1.20	1.17	1.14							
6	1.45	1.37	1.33	1.29	1.26	1.21							
7	1.62	1.50	1.44	1.39	1.34	1.28	1.21	1.12					
8	1.78	1.63	1.55	1.48	1.42	1.36	1.28	1.18	1.07				
9	1.95	1.77	1.66	1.58	1.51	1.43	1.34	1.24	1.12				
10	2.11	1.90	1.77	1.67	1.59	1.50	1.41	1.30	1.18	1.03			
11	2.28	2.03	1.88	1.77	1.67	1.58	1.48	1.36	1.23	1.08			
12	2.45	2.16	1.99	1.86	1.75	1.65	1.54	1.42	1.29	1.13	0.96		
13		2.30	2.10	1.96	1.84	1.72	1.61	1.48	1.34	1.19	1.01		
14		2.43	2.21	2.05	1.92	1.80	1.68	1.54	1.40	1.24	1.06	0.85	
15			2.32	2.15	2.00	1.87	1.74	1.60	1.45	1.29	1.10	.90	
16			2.43	2.24	2.09	1.95	1.81	1.66	1.51	1.34	1.15	.94	0.71
17				2.34	2.17	2.02	1.87	1.72	1.56	1.39	1.20	.99	.76
18				2.43	2.25	2.09	1.94	1.78	1.62	1.44	1.25	1.03	.80
19					2.33	2.17	2.01	1.84	1.67	1.49	1.29	1.08	.84
20					2.42	2.24	2.07	1.90	1.73	1.54	1.34	1.12	.88
21						2.31	2.14	1.97	1.78	1.59	1.39	1.16	.92
22						2.39	2.21	2.03	1.84	1.64	1.43	1.21	.96
23							2.27	2.09	1.90	1.70	1.48	1.25	1.00
24							2.34	2.15	1.95	1.75	1.53	1.30	1.05

As an example of the use of these tables, let us assume a sampling point where two pinyons are "in" on an angle gage having a basal area factor of 40 ft^2/acre, and one juniper crown is closer than one-half of its average crown diameter to the sampling point. Height, crown diameter, and stump diameter of the two pinyons are:

	Pinyon No. 1	Pinyon No. 2
Height (ft)	20	18
Crown diameter (ft)	14	12
Stump diameter (inches)	12	8

The juniper has an average crown diameter of 12 ft and two stems at breast height 4 inches and 7 inches in diameter.

Estimated pinyon cordwood (table 5) at the sampling point is:

$$Bf \sum_{i}^{n} \left(\frac{\hat{W}}{B}\right) = 40 \text{ ft}^2\text{/acre x } (240 \text{ lb/ft}^2 + 195 \text{ lb/ft}^2) = 17{,}400 \text{ lb/acre}$$

The average ovendry weight of a solid cubic foot of pinyon cordwood (with bark) is 29 lb. The estimated pinyon cordwood in cubic feet per acre is:

$$17{,}400 \text{ lb/acre} \div 29 \text{ lb/ft}^3 = 600 \text{ ft}^3\text{/acre}$$

For the sample juniper tree, the equivalent *Db* is $\sqrt{4^2 + 7^2} = 8$ inches. Table 7 shows 0.77 b/ft^2 of crown area for a single stem juniper with a *Db* of 8 inches and an average crown diamter of 12 ft. Since this is a two-stem juniper, the estimate is reduced by 0.14 to 0.63 lb/ft^2. stimated juniper cordwood is:

$$\frac{k}{4} \sum_{i}^{n} \left(\frac{\hat{W}}{Ca}\right) = \frac{43{,}540 \text{ ft}^2\text{/acre}}{4} \text{ x } 0.63 \text{ lb/ft}^2 = 6{,}861 \text{ lb/acre}$$

The average ovendry weight of a solid cubic foot of juniper cordwood (with bark) is 24 lb. he estimated juniper cordwood in cubic feet per acre is:

$$6{,}861 \text{ lb/acre} \div 24 \text{ lb/ft}^3 = 286 \text{ ft}^3\text{/acre}$$

Total estimated cordwood at the sampling point is 886 ft^3/acre.

Estimated pinyon slash (table 6) is:

$$Bf \sum_{i}^{n} \left(\frac{\hat{S}}{B}\right) = 40 \text{ ft}^2\text{/acre x } (375 \text{ lb/ft}^2 + 443 \text{ lb/ft}^2) = 32{,}720 \text{ lb/acre.}$$

Estimated juniper slash (table 8) is:

$$\frac{k}{4} \sum_{i}^{n} \left(\frac{\hat{S}}{Ca}\right) = \frac{43{,}560 \text{ ft}^2\text{/acre}}{4} \text{ x } 1.55 \text{ lb/ft}^2 = 16{,}880 \text{ lb/acre.}$$

Total estimated slash at the sampling point is 49,600 lb/acre, or about 25 tons per acre (endry weight).

A survey of a tract would consist of a number of sampling points and the average of the per acre estimates at each point is the estimated pounds (or cubic feet) per acre for the tract. Pinyon cordwood weight (Wp) in a tract can be calculated by:

$$Wp = \frac{A \cdot Bf}{N} \sum^{N} \sum^{n} \left(\frac{\hat{W}}{B}\right)_i$$

in which

A is the tract area (acres)
N is the number of sampling points
n is the number of sample pinyons at a sampling point
Bf is the basal area factor (ft^2/acre)
$\left(\frac{\hat{W}}{B}\right)_i$ is the estimated cordwood weight per square foot basal area of each pinyon (from table 5

This estimate can be converted to cubic foot volume (Vp) by dividing by 29 lb/ft^3. If a of 40 ft^2/acre is used:

$$Vp = \frac{1.38 \cdot A}{N} \sum^{N} \sum^{n} \left(\frac{\hat{W}}{B}\right)_i$$

Juniper cordwood weight (Wj) in a tract can be calculated by:

$$Wj = \frac{10{,}890 \cdot A}{N} \sum^{N} \sum^{n} \left(\frac{\hat{W}}{Ca}\right)_i$$

in which $\left(\frac{\hat{W}}{Ca}\right)_i$ is the estimated cordwood weight per square foot of crown area of each sample juniper from table 7. This estimate can be converted to cubic foot volume by dividing by 24 lb/ft^3, or calculated more directly by:

$$Vj = \frac{454 \cdot A}{N} \sum^{N} \sum^{n} \left(\frac{\hat{W}}{Ca}\right)_i$$

The cubic foot volumes can be converted to cords, if desired, by dividing by the number solid cubic feet in a cord. There are roughly 75 solid cubic feet in a cord of pinyon and juniper. But the amount varies with the size, length, and shape of the material, and how carefully it is stacked.

Predicted slash weights in a tract can be calculated in the same manner as cordwood weights using tables 6 and 8.

Aboveground Biomass

Pinyon cordwood per unit basal area can be estimated reliably if average crown diameter and tree height are known. Pinyon slash per unit basal area can be estimated reliably if average crown diameter and stump diameter are known. Reliable estimation of aboveground biomass (cordwood plus slash) per unit basal area requires all three variables: crown diameter, height, and stump diameter (table 2). (Tables with three input variables are cumbersome and are not included in this paper.) Aboveground biomass can be calculated either by using a computer or programabl calculator to solve the regression equation or by simply adding estimated slash and estimate cordwood together. The second method is nearly as precise as the first.

Returning to the hypothetical sampling point used as an example in the last section, the estimated total aboveground biomass of pinyon per acre obtained by adding cordwood and slash is:

17,400 lb/acre cordwood + 32,720 lb/acre slash = 50,129 lb/acre.

If we use the "total" equation in table 2, estimated aboveground biomass per square foot of basal area is 601 lb/ft^2 for pinyon No. 1 and 604 lb/ft^2 for pinyon No. 2. This yields an estimate of:

$$Bf \sum^{n} \left(\frac{W}{B}\right)_i = 40 \text{ ft}^2/\text{acre} \times (601 + 604) = 48{,}200 \text{ lb/acre.} \qquad \{\text{pinyon}\}.$$

Height apparently has little predictive value for juniper biomass. Aboveground biomass per square foot of crown area of juniper can be reliably estimated if only crown diameter and stem diameter at breast height are known. Table 9, based on the "total" equation in table 4, provides estimated aboveground biomass in pounds per square foot of crown area of juniper. The juniper at the example sampling point has an estimated 2.26 lb/ft^2, yielding an estimate of:

$$\frac{k}{4} \sum^{n} \left(\frac{M}{Ca}\right)_i = 10{,}890 \times 2.26 = 24{,}611 \text{ lb/acre.} \qquad \{\text{juniper}\}$$

of juniper at the sampling point. Estimated aboveground biomass of pinyon and juniper at the sampling point is 72,811 lb/acre, or about 36 tons per acre.

Table 9.--*Juniper aboveground biomass in pounds per square foot of tree crown area*

	Crown diameter (feet)												
.b.h.	8	10	12	14	16	18	20	22	24	26	28	30	32
nches	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	*Pounds per square foot*			- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
4	1.52	1.38	1.32	1.29	1.27								
5	1.87	1.67	1.55	1.49	1.45	1.41							
6	2.23	1.95	1.79	1.69	1.62	1.57	1.52						
7	2.58	2.23	2.03	1.89	1.80	1.73	1.66	1.59					
8	2.94	2.52	2.26	2.10	1.98	1.89	1.80	1.72	1.64				
9	3.29	2.80	2.50	2.30	2.16	2.04	1.95	1.85	1.76				
0	3.65	3.08	2.74	2.50	2.33	2.20	2.09	1.98	1.88	1.77			
1	4.00	3.37	2.97	2.71	2.51	2.36	2.23	2.11	1.99	1.88			
2	4.36	3.65	3.21	2.91	2.69	2.52	2.37	2.24	2.11	1.99	1.85		
3		3.93	3.44	3.11	2.87	2.67	2.51	2.37	2.23	2.10	1.96		
		4.22	3.68	3.31	3.04	2.83	2.65	2.50	2.35	2.20	2.06	1.90	
			3.92	3.52	3.22	2.99	2.80	2.63	2.47	2.31	2.16	2.00	
			4.15	3.72	3.40	3.15	2.94	2.75	2.59	2.42	2.26	2.09	1.92
				3.92	3.57	3.30	3.08	2.88	2.70	2.53	2.36	2.19	2.01
				4.12	3.75	3.46	3.22	3.01	2.82	2.64	2.46	2.28	2.10
					3.39	3.62	3.36	3.14	2.94	2.75	2.56	2.38	2.19
					4.11	3.78	3.50	3.27	3.06	2.86	2.66	2.47	2.27
2						3.93	3.65	3.40	3.18	2.97	2.77	2.57	2.36
2						4.09	3.79	3.53	3.29	3.08	2.87	2.66	2.45
2							3.93	3.66	3.41	3.19	2.97	2.76	2.54
2							4.07	3.79	3.53	3.29	3.07	2.85	2.63

Foliage and Fine Fuels

Point sampling procedures for estimating foliage and fine fuels in a stand are the same as those described for estimating slash. Pinyon foliage and fine fuels per unit basal area can be estimated if crown diameter and stump diameter are known. Juniper foliage and fine fuels per unit crown area can be estimated if crown diameter and diameter breast height are known. Tables of estimated foliage and fine fuels are not presented in this paper. They can be prepared, if needed, from the appropriate equations in tables 1 through 4.

Continuing with the example sampling point, the estimated foliage weights per unit basal area of the two sample pinyons are 91.4 lb/ft^2 and 127.6 lb/ft^2 (from the foliage equation in table 2). Estimated pinyon foliage per acre at the sampling point is:

$$Bf \sum^{n} \left(\frac{W}{B}\right)_i = 40 \text{ ft}^2/\text{acre} \times (91.4 + 127.6) \text{ lb/ft}^2 = 8{,}760 \text{ lb/acre.}$$

According to the foliage equation in table 4, the estimated foliage of the sample juniper is 0.681 lb/ft^2. Estimated juniper foliage per acre is 10,890 x 0.681 = 7,416 lb/acre, bringing the total estimated foliage at the sampling point to 16,176 lb/acre, or about 8 tons per acre.

Estimated weight of fine fuels at the sampling point is 25,284 lb/acre, calculated in the same manner as foliage but using the fine fuels equations in tables 2 and 4.

Canopy Cover

Better ways exist for estimating canopy cover of pinyon-juniper stands than the point sampling procedures in this paper. If one is only interested in measuring cover, the line interception method (Canfield 1941) yields better estimates with less field effort. If an estimate of canopy cover is desired in conjunction with a survey of stand biomass, then the computations in this section provide the estimate without requiring additional field measurem ts.

Estimated juniper canopy cover is simple to calculate. If only junipers with crowns act lly intersecting the sample point were tallied, juniper canopy cover of a stand would be calculat by dividing the number of tallied junipers by the number of sample points and multiplying by 100. Since the point-sampling procedures described in this paper increase the sampling probability of juniper by a factor of four, the estimated juniper canopy cover for a stand is:

$$\text{Juniper cover \%} = \frac{100\%}{4 \cdot N} \sum^{N} n_i$$

where N is the number of sampling points and n_i is the number of juniper trees tallied at ea sampling point.

Estimated pinyon canopy cover at a sampling point is calculated by multiplying the sum the ratios of crown area (Ca) to basal area (B) of each sampled pinyon by the basal area fac r (Bf):

$$\text{Pinyon cover \% (point estimate)} = 100\% \times Bf \times \sum^{n} \left(\frac{Ca}{B}\right)_i .$$

After making appropriate substitutions and correcting for dimensions, the metric equati is:

$$\text{Pinyon cover \% (point estimate)} = 100 \times Bf \times \sum^{n} \left(\frac{C}{Ds}\right)_i^2$$

where Bf is the basal area factor in m^2/ha, C is average crown diameter in meters, and Ds is stump diameter in centimeters. In U.S. units the equation is:

$$\text{Pinyon cover \% (point estimate)} = 0.3306 \times Bf \times \sum^{n} \left(\frac{C}{Ds}\right)^2_i$$

where Bf is in ft^2/acre, C is in feet, and Ds is in inches.

The average pinyon cover of a stand is:

$$\text{Pinyon cover \% (stand estimate)} = \frac{100 \cdot Bf}{N} \sum^{N}\sum^{n} \left(\frac{C}{Ds}\right)^2_i \qquad \{\text{metric}\}$$

or

$$\frac{0.3306\ Bf}{N} \sum^{N} \sum^{n} \left(\frac{C}{Ds}\right)^2_i \qquad \{\text{U.S.}\}$$

At the hypothetical sampling point, calculated canopy cover is 25 percent juniper and 48 ercent pinyon.

Trees per Unit Area

Tree density (trees per hectare or per acre) can be estimated from the data obtained by oint sampling. For pinyon, estimated tree density at a sampling point is calculated by summing he reciprocals of the basal area (B_i) of the sample pinyons and multiplying by the basal area ctor (Bf).

$$\text{Pinyon density (point estimate)} = Bf \sum^{n} \frac{1}{B_i}\ .$$

After substituting $\frac{\pi Ds^2}{4}$ for B and correcting for dimensions, the metric equation is:

$$\text{Pinyon trees per hectare (point estimate)} = 12{,}732 \times Bf \sum^{n} \left(\frac{1}{Ds}\right)^2_i$$

where Bf is the basal area factor in m^2/ha and Ds is stump diameter in centimeters. In U.S. units the equation is:

$$\text{Pinyon trees per acre (point estimate)} = 183 \times Bf \sum^{n} \left(\frac{1}{Ds}\right)^2_i$$

with Bf in ft^2/acre and Ds in inches.

The estimated pinyon density for a stand is:

$$\text{Pinyon trees per hectare (stand estimate)} = \frac{12{,}732 \times Bf}{N} \sum^{N} \sum^{n} \left(\frac{1}{Ds}\right)^2_i$$

or

$$\text{Pinyon trees per acre (stand estimate)} = \frac{183 \times Bf}{N} \sum^{N} \sum^{n} \left(\frac{1}{Ds}\right)^2_i$$

where N is the number of sampling points and n is the number of sample pinyons at each point.

Estimated juniper tree density at a sampling point is proportional to the sum of the reciprocals of the crown areas of the sample junipers.

$$\text{Juniper density (point estimate)} = \frac{k}{4} \sum^{n} \frac{1}{Ca_i} = \frac{k}{\pi} \sum^{n} \left(\frac{1}{C}\right)^2_i$$

Ca_i is the crown area (m^2 or ft^2) of each sample tree, k is 10 000 m^2/ha or 43,560 ft^2/acr, and C is average crown diameter (m or ft). The estimated juniper density for a stand is:

$$\text{Juniper trees per hectare (stand estimate)} = \frac{10,000}{\pi} \sum^{N} \sum^{n} \left(\frac{1}{C}\right)^2_i \qquad \text{\{metric\}}$$

or

$$\text{Juniper trees per acre (stand estimate)} = \frac{43,560}{\pi} \sum^{N} \sum^{n} \left(\frac{1}{C}\right)^2_i \qquad \text{\{U.S.\}}$$

Calculated tree density at the hypothetical sampling point is 165 pinyon trees per acre and 96 juniper trees per acre.

Stand Basal Area

Estimated stand basal area of pinyon at each sampling point is obtained by multiplying t basal area factor by the number of tallied trees. The stand estimate in either m^2/ha or ft^2/ acre is:

$$\text{Stand basal area (pinyon)} = \frac{Bf}{N} \sum^{N} n_i$$

where n_i is the number of tallied pinyon trees at each sampling point. Since stump height (15 cm or 6 inches) is used as the target level for the angle gage, the estimated basal area also at stump height rather than at conventional breast height.

Estimated stand basal area of juniper at a sampling point is proportional to the sum of he ratios of basal area to crown area of the sample juniper trees.

$$\text{Stand basal area (juniper)} = \frac{k}{4} \sum^{n} \left(\frac{B}{Ca}\right)_i$$

where B is tree basal area (m^2 or ft^2), Ca is crown area (m^2 or ft^2), and k is 10 000 m^2/ha 43,560 ft^2/acre.

For consistency, it is desirable to express juniper basal area at the same height as pinyon. To eliminate the need for diameter measurements at stump height, which are often difficult on junipers, regression equations have been developed to estimate the ratio of stu basal area to crown area:

$$\widehat{\left(\frac{k \cdot B}{Ca}\right)} = 32.467 - 0.4705\ Db + 1.221\ \left(\frac{Db}{C}\right)^2 \qquad \text{\{metric\}}$$

$$\widehat{\left(\frac{k \cdot B}{Ca}\right)} = 141.4 - 5.21\ Db + 369.4\ \left(\frac{Db}{C}\right)^2 \qquad \text{\{U.S.\}}$$

in which $\left(\frac{k \cdot B}{Ca}\right)$ is estimated basal area at stump height divided by crown area (m^2/ha or ft^2/acre), Db is diameter breast height (cm or inches), and C is average crown diameter (m or ft). These equations are based on the same data as the preceding biomass equations. The R^2 is 0.472 and CVR is 23.8 percent for these equations.

Ratios of juniper stump basal area to crown diameter (in square feet per acre) at various crown diameters and breast height diameters are listed in table 10. The sample juniper at the example sampling point, with an average crown diameter of 12 ft and an equivalent Db of 8 inches, has a basal area to crown ratio of 264 ft^2/acre. The estimated stand basal area of juniper at the sampling point is:

$$\frac{1}{4} \sum^{n} \left(\frac{k \cdot B}{Ca}\right)_i = \frac{264}{4} = 66\ ft^2/\text{acre}.$$

Total estimated stand basal area at the sampling point is 146 ft^2/acre (80 + 66).

Table 10.--*Ratios of juniper stump basal area to tree crown area*

.b.h.	Crown diameter (feet)												
	8	10	12	14	16	18	20	22	24	26	28	30	32
ches						*Square feet per acre*							
4	213	180	162	151	144								
5	260	208	179	162	151	144							
6	318	243	202	178	162	151	143						
7	388	286	231	197	176	161	150	142					
8	469	336	264	220	192	173	159	149	141				
9	562	394	302	247	211	187	169	156	146				
0	666	459	346	278	234	203	182	166	153	144			
1	782	531	394	312	259	222	196	176	162	150			
2	910	611	448	350	287	243	212	189	171	158	147		
3		698	507	392	318	266	230	203	182	166	153		
		792	571	438	351	292	249	218	194	176	161	149	
			640	487	388	320	271	235	208	186	169	156	
			715	541	427	350	294	253	222	198	179	163	150
				598	470	383	320	273	238	211	189	171	157
				658	515	417	347	295	255	225	200	181	165
1					563	454	376	318	274	240	213	191	173
2					614	493	407	342	294	256	226	201	181
2						535	439	369	315	273	240	213	191
2						579	474	396	337	291	255	225	201
2							510	425	361	311	271	239	212
2							548	456	386	331	288	253	224

Growth Rates

Procedures for point sampling decadal growth rates in terms of stand basal area, total abov ground biomass, and cordwood are described in this section. Growth rate estimates require measurement of radial growth in addition to the measurements for biomass estimates. Measurement of decadal radial growth can be made on cores obtained with an increment hammer at stump height on pinyon and at breast height on juniper. It is usually difficult to obtain usable cores from juniper with an increment borer, but an increment hammer works well if the bit is kept sharp.

Growth rates during the 10 years prior to sampling were calculated for the 72 pinyons and 33 junipers, using the stem analysis procedures described by Meeuwig and Budy (1979) and by Meeuwig (1979). The regression equations in table 11 were developed by the same screen regressi procedures that were used for the biomass equations in this paper, and are applied in the same manner. The equations provide estimates of decadal growth rates of tree basal area, cordwood, and total aboveground biomass of singleleaf pinyon and Utah juniper in both metric and U.S. units. Except for pinyon basal area growth and juniper total growth, the equations require at least three input variables and are not easily presentable in tabular form.

Pinyon basal area growth per unit basal area is, of course, closely correlated with the ratio of radial wood growth to diameter outside bark. Slight variation in the bark thickness/diamete ratios is the main reason for lack of perfect correlation. Table 12 gives basal area growth/basal area ratios over a range of radial growth/diameter ratios. Since both ratios are dimensionless except for time, the table is applicable in both metric and U.S. units.

Continuing with the example from the preceding sections, let us assume that the average combined width of the last 10 complete annual rings in cores from the 12-inch diameter pinyon is 0.5 inches and that of the 8-inch diameter pinyon is 0.4 inches. The radial growth/diameter ratios (X) are 0.042 and 0.050, respectively. The estimated basal area growth/basal area ratio (from the pinyon basal area growth equation in table 11, or interpolated from table 12) are 0.19 and 0.22 ft^2/decade/ft^2. Estimated pinyon stand basal area growth at the sampling point i

$$Bf \sum^{n} \left(\frac{\widehat{\Delta B}}{B}\right)_i = 40\ \text{ft}^2/\text{acre} \times (0.19 + 0.22)/\text{decade} = 16.4\ \text{ft}^2/\text{acre/decade}.$$

No tables are presented in this paper for the other growth equations. They can be used more efficiently with computers or programable calculators than with tables. From the appropriate equations in table 11, estimated pinyon cordwood growth and aboveground biomass growth at the hypothetical sampling point are:

Pinyon cordwood growth = 40 ft^2/acre x (69 + 66) lb/ft^2/decade = 5,400 lb/acre/decade

Pinyon aboveground growth = 40 ft^2/acre x (137 + 167) lb/ft^2/decade = 12,160 lb/acre/deca

For pinyons with more than one stem at stump height, the cores are taken from the largest stem, and then the average combined width of the 10 rings is divided by the diameter (outside bark) of that stem to determine the radial growth/diameter growth ratio. Equivalent radial growth is calculated by multiplying this ratio by the equivalent diameter. This simplified procedure gives essentially the same results as analyzing the growth of all stems.

For juniper with more than one stem at breast height, the equivalent radial growth (Rb) determined in the same manner:

$$Rb = \frac{Rb_1}{Db_1} \times \sqrt{Db_1{}^2 + Db_2{}^2 + \,..Db_n{}^2}$$

This sample juniper has two stems with diameters of 7 and 4 inches. If cores taken at breast height on the 7-inch stem show an average radial wood growth of 0.35 inches in 10 year then

$$Rb = \frac{0.35}{7} \times \sqrt{7^2 + 4^2} = 0.40 \text{ inches}$$

Table 11.--*Regression equations for estimating basal area, aboveground biomass, and cordwood growth rates of pinyon and juniper trees. The dependent variable* (Y) *is decadal growth divided by basal area for pinyon, or decadal growth divided by crown area for juniper. Independent variables are defined at the bottom of the table*

Equations	$\bar{Y}$	SDR	CVR	R^2
			Percent	
Metric				
Pinyon basal area growth/basal area	(cm^2/decade/m^2)			
$\hat{Y} = 48910X - 66590X^2 - 36$	2298	146	6.3	0.991
Pinyon total aboveground biomass growth/basal area	(kg/decade/m^2)			
$\hat{Y} = 1408X \cdot H + 4055X \cdot C - 423.6Rs + 120$	802	154	19.2	.877
Pinyon cordwood growth/basal area	(kg/decade/m^2)			
$\hat{Y} = 947X \cdot H - 3098X^2 \cdot H + 25.8Rs\ H - 128Rs + 91$	353	66	18.8	.822
Juniper basal area growth/crown area	(cm^2/decade/m^2)			
$\hat{Y} = 55.68\frac{Rb}{C} - 2.261\frac{Rb^2}{C} + 0.2205Db \cdot Rb - 8.06Rb - 0.706$	11.54	1.70	14.8	.972
Juniper total aboveground biomass growth/crown area	(kg/decade/m^2)			
$\hat{Y} = 3.285Rb - 0.3332Rb \cdot C + 0.267$	2.622	0.511	19.5	.919
Juniper cordwood growth/crown area	(kg/decade/m^2)			
$Y = 0.1499\frac{Db \cdot Rb}{C} + 13.51\frac{Rb^2}{C \cdot Db} - 4.466\frac{Rb \cdot Sb^{1/2}}{Db} + 0.083$	0.810	0.167	20.6	.904
U.S.				
Pinyon basal area growth/basal area	(ft^2/decade/ft^2)			
$\hat{Y} = 4.89X - 6.66X^2 - 0.0036$	0.2300	0.0146	6.3	.991
Pinyon total aboveground biomass growth/basal area	(lb/decade/ft^2)			
$\hat{Y} = 87.89X \cdot H + 253.13X \cdot C - 220.35Rs + 24.6$	164.2	31.5	19.2	.877
Pinyon cordwood growth/basal area	(lb/decade/ft^2)			
$\hat{Y} = 59.12X \cdot H - 193.4X^2 \cdot H + 4.09Rs \cdot H - 66.6Rs + 18.6$	72.2	13.5	18.8	.822
Juniper basal area growth/crown area	(ft^2/decade/acre)			
$\hat{Y} = 2021\frac{Rb}{C} - 208.7\frac{Rb^2}{C} + 6.197Db \cdot Rb - 89.2Rb - 3.08$	50.27	7.41	14.8	.972
Juniper total aboveground biomass growth/crown area	(lb/decade/ft^2)			
$\hat{Y} = 1.709Rb - 0.0528Rb \cdot C + 0.055$	0.537	0.105	19.5	.919
Juniper cordwood growth/crown area	(lb/decade/ft^2)			
$\hat{Y} = 0.650\frac{Db \cdot Rb}{C} + 9.08\frac{Rb}{C \cdot Db} - 0.915\frac{Rb \cdot Sb^{1/2}}{Db} + 0.017$	0.166	0.034	20.6	.904

Definition of Symbols

H = tree height (meters or feet)
C = average crown diameter (meters or feet)
Ds = diameter outside bark at stump height (centimeters or inches)
Rs = radial wood growth at stump height in the last 10 years (centimeters per decade or inches per decade)
X = Rs/Ds (dimensionless)
Db = diameter outside bark at breast height (centimeters or inches)
Rb = radial wood growth at breast height in the last 10 years (centimeters per decade or inches per decade)
Sb = number of stems larger than 76 mm (3 inches) at breast height

Table 12.--*Ratio of decadal basal area growth* (ΔB) *to tree basal area* (B) *as a function of the ra of decadal radial wood growth* (Rs) *to stump diameter* (Ds) *of pinyon. The ratios are dimensionless*

Rs/Ds	ΔB/B
0.01	0.04
.02	.09
.03	.13
.04	.18
.05	.22
.06	.26
.07	.30
.08	.34
.09	.38
.10	.41
.11	.45
.12	.48
.13	.52
.14	.55
.15	.58
.16	.60
.17	.63
.18	.66
.19	.69
.20	.71

From the last three equations in table 11, estimated growth at the sampling point is:

$$\text{Juniper basal area growth} = \frac{45.65 \text{ ft}^2\text{/decade/acre}}{4} = 11.4 \text{ ft}^2\text{/acre/decade}$$

$$\text{Juniper total growth} = \frac{43{,}560 \text{ ft}^2\text{/acre}}{4} \text{ X } 0.485 \text{ lb/decade/ft}^2 = 5{,}282 \text{ lb/acre/decade}$$

$$\text{Juniper cordwood growth} = \frac{43{,}560 \text{ ft}^2\text{/acre}}{4} \text{ X } 0.163 \text{ lb/decade/ft}^2 = 1{,}775 \text{ lb/acre/deca}$$

Juniper increment cores are taken at breast height because it is easier to obtain represe-ative cores there, but basal area growth is estimated at stump height to be consistent with th pinyon estimates. No conversion from square feet to acres is needed in the juniper basal area growth calculation because the regression estimate is in square feet per decade per acre of cr m area.

Estimated decadal growth of pinyon and juniper combined at the sampling point is:

Basal area: 28 ft^2/acre/decade

Total aboveground biomass: 8.7 tons/acre/decade

Cordwood: 3.6 tons/acre/decade or 260 ft^3/acre/decade

Estimates of stand growth are calculated in the same manner as estimates of stand biomass. The generalized equations are:

$$\text{Pinyon decadal growth (stand estimate)} = \frac{A \cdot Bf}{N} \sum^{N} \sum^{n} \hat{y}_i$$

$$\text{Juniper decadal growth (stand estimate)} = \frac{A \cdot k}{4N} \sum^{N} \sum^{n} \hat{y}_i$$

in which A = stand area in hectares or acres, Bf is the basal area factor in m^2/ha or ft^2/acre, N is the number of sampling points, n is the number of sample trees at each sampling point, $\hat{y}_i$ is the regression estimates of the ratio of decadal growth to basal area (pinyon) or to crown area (juniper), and k is 10 000 m^2/ha or 43,560 ft^2/acre.

LINE-INTERSECT SAMPLING

The procedures in this section are modifications and elaborations of the cordwood sampling procedure described by Meeuwig and others (1978). A number of transect lines are laid out, preferably with staff compass and tape, in some predetermined design. Except as noted below, trees are tallied if any portion of their crown is over a transect line. A tree would not be tallied if the center of its root crown lies beyond either end of a transect. If transects are laid out in a continuous series of line segments, this exception applies only to the two ends of the series. Within the series, a borderline tree may be tallied in either transect that its crown intersects, but not both.

The length of the transect can vary, depending on stand conditions. For most well-stocked tands, 30 m or 100 ft is about right. In dense stands, 20 m or 66 ft may be more convenient. n more open stands, it may be desirable to use 40 m or 132 ft. For statistical reasons, it is esirable to have at least two sample trees in each transect.

Estimates of biomass per unit land area, stand basal area, growth rates, and other stand haracteristics can be calculated for each transect. Estimated biomass per unit area for a ransect is:

$$\frac{M}{A} = \frac{k}{L} \sum^{n} \widehat{\left(\frac{M}{C}\right)}_i$$

In metric units, $\frac{M}{A}$ is estimated biomass in kg/ha, k is 10 000 m^2/ha, L is transect length in ters, n is the number of sample trees in the transect, and $\widehat{(\frac{M}{C})}_i$ is the ratio of biomass to erage crown diameter (kg/m) as estimated by regression. In U.S. units, $\frac{M}{A}$ is pounds per acre, k is 43,560 ft^2/acre, L is feet, and $\widehat{(\frac{M}{C})}_i$ is pounds per foot.

Estimated biomass for a stand or tract is:

$$\text{Biomass (stand estimate)} = \frac{A \cdot k}{N \cdot L} \sum^{N} \sum^{n} \widehat{\left(\frac{M}{C}\right)}_i$$

in which A is area of the stand in hectares or acres and N is the number of transects.

Regression equations for estimating the ratios of biomass components to average crown diameters are presented in metric units in table 13 and in U.S. units in table 14. These equations were developed in essentially the same manner as the point-sampling equations and use the same set of input variables.

Line-intersect procedures for estimating the various biomass components, canopy cover, tree density, stand basal area, and growth rates are described in the following sections. A hypothetical transect is used throughout as an example to illustrate the procedures. This transect is 100 ft long and intersects five trees:

	Tree number				
	1	2	3	4	5
Species	P	P	P	J	J
Crown diameter (ft)	10	14	12	16	18
Height (ft)	16	20	18	--	--
Diameter, stump (inches)	6	12	8	--	--
Diameter b.h. (inches)	--	--	--	10	6 & 7
Equivalent diameter (inches)	--	--	--	--	9
Radial wood growth (inches/decade)	0.35	0.50	0.40	0.40	0.35

No height measurements are required for juniper. Stem diameter is measured at stump height (15 cm or 6 inches) on pinyon and at breast height (137 cm or 4.5 ft) on juniper. Sample tree 5 has two stems at breast height; its equivalent diameter is calculated as described earlier in this paper.

Table 13.--*Regression equations for estimating mass (kg) per meter of crown width of pinyon and juniper trees. The dependent variable* (Y) *is component mass divided by crown width (kg/m). Ds is stem diameter (cm) at stump height (15 cm) and* Db *is stem diameter (cm) at breast height (137 cm).* H *is tree height and* C *is average crown diameter, both in meters. Sb is the number of stems larger than 7.6 cm diameter at breast height*

Component	Regression equation	$\bar{Y}$	SDR	CVR	R^2
		- - *kg/m*	- -	*Percent*	
Pinyon					
Total	$\hat{Y} = 0.7228Ds + 0.2269Ds \cdot H - 0.0004256Ds^2 \cdot H - 11.44$	60.97	8.24	13.5	0.97
Cordwood	$\hat{Y} = 0.1734Ds \cdot H - 0.7103Ds + 0.008597Ds^2 + 0.722$	30.70	7.15	23.3	.96
Slash	$\hat{Y} = 1.981Ds - 0.01227Ds^2 - 16.62$	30.27	6.24	20.6	.88
Fine fuels	$\hat{Y} = 0.7468Ds - 0.00503Ds^2 - 3.60$	13.55	3.71	24.4	.76
Foliage	$\hat{Y} = 0.4380Ds - 0.00295Ds^2 - 2.21$	7.85	2.19	27.9	.71
Juniper					
Total	$\hat{Y} = 3.214C + 1.349Db - 6.83$	33.05	6.86	20.7	0.9
Cordwood	$\hat{Y} = -0.7177Db + 0.02157Db^2 - 0.8481\frac{Db}{Sb} + 1.554\frac{Db}{Sb^{\frac{1}{2}}} + 1.71$	11.00	2.14	19.4	.9
Slash	$\hat{Y} = 10.82C + 2.425\frac{Db}{C} - 0.5688C^2 - 22.55$	22.05	4.99	22.6	.8
Fine fuels	$\hat{Y} = 5.582C + 1.334\frac{Db}{C} - 0.3585C^2 - 10.61$	11.42	2.60	22.8	.7
Foliage	$\hat{Y} = 4.343C + 1.136\frac{Db}{C} - 0.2809C^2 - 8.48$	9.06	2.15	23.7	.7

Table 14.--*Regression equations for estimating weight (lb) per foot of crown width of pinyon and juniper trees. The dependent variable is component weight divided by crown width (lb/ft).* Ds *is stem diameter in inches at stump height (6 inches) and* Db *is stem diameter at breast height (4.5 feet).* H *is tree height in feet and* C *is average crown diameter in feet.* Sb *is the number of stems larger than 3 inches diameter at breast height*

Component	Regression equation	$\bar{Y}$	SDR	CVR	R^2
		- - *Lb/ft*	- -	*Percent*	
Pinyon					
Total	$\hat{Y} = 1.234Ds + 0.1180Ds \cdot H - 0.000562Ds^2 \cdot H - 7.69$	40.97	5.54	13.5	0.976
Cordwood	$\hat{Y} = 0.0902Ds \cdot H + 0.0373Ds^2 - 1.212Ds + 0.48$	20.63	4.80	23.3	.964
Slash	$\hat{Y} = 3.381Ds - 0.0532Ds^2 - 11.17$	20.34	4.19	20.6	.881
Fine fuels	$\hat{Y} = 1.275Ds - 0.0218Ds^2 - 2.42$	9.11	2.49	24.4	.761
Foliage	$\hat{Y} = 0.748Ds - 0.0128Ds^2 - 1.48$	5.28	1.47	27.9	.715
Juniper					
Total	$\hat{Y} = 0.6583C + 2.303Db - 4.59$	22.21	4.61	20.7	.906
Cordwood	$\hat{Y} = -1.225Db + 0.0935Db^2 - 1.448\frac{Db}{Sb} + 2.652\frac{Db}{Sb^{\frac{1}{2}}} + 1.152$	7.39	1.44	19.4	.968
Slash	$\hat{Y} = 2.216C + 13.58\frac{Db}{C} - 0.0355C^2 - 15.15$	14.82	3.35	22.6	.834
Fine fuels	$\hat{Y} = 1.143C + 7.470\frac{Db}{C} - 0.0224C^2 - 7.13$	7.67	1.75	22.8	.773
Foliage	$\hat{Y} = 0.890C + 6.362\frac{Db}{C} - 0.0175C^2 - 5.70$	6.09	1.44	23.7	.757

Cordwood and Slash

Estimates of pinyon cordwood, pinyon slash, juniper cordwood, and juniper slash (all in pounds per foot of crown diameter) are in tables 15 through 18. These tables are based on the equations in table 14.

From table 15, the cordwood estimates for the three sample pinyons on the example transect are 3, 13, and 6 lb/ft. The pinyon cordwood estimate for the example transect is:

$$\frac{k}{L}\sum^{n}\left(\frac{\hat{W}}{C}\right)_i = \frac{43{,}560\ \mathrm{ft}^2/\mathrm{acre}}{100\ \mathrm{ft}} \times (3 + 13 + 6)\,\mathrm{lb/ft} = 9{,}583\ \mathrm{lb/acre}$$

If cubic volume is desired, the estimate is divided by 29 lb/ft^3 (the specific weight of pinyon cordwood), converting the estimate to 330 ft^3 per acre.

Table 15.--*Pinyon cordwood in pounds per foot of average crown diameter*

Stump diameter	Height (feet) 12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
Inches	*Pounds per foot*														
6	1	2	3	4	5	6	8	9	10						
7	1	3	4	5	6	8	9	10	12						
8	2	3	5	6	8	9	10	12	13	15					
9	2	4	6	7	9	10	12	14	15	17					
10	3	5	7	8	10	12	14	16	17	19	21				
11	4	6	8	10	12	13	15	17	19	21	23				
12	4	6	9	11	13	15	17	19	22	24	26	28			
13	5	7	10	12	14	17	19	22	24	26	29	31			
14	6	9	11	14	16	19	21	24	26	29	31	34	36		
15	7	10	12	15	18	20	23	26	29	31	34	37	39		
16	8	11	14	17	20	22	25	28	31	34	37	40	43	45	
17	9	12	15	18	21	24	27	31	34	37	40	43	46	49	
18	10	13	17	20	23	26	30	33	36	39	43	46	49	52	5
19	11	15	18	22	25	29	32	35	39	42	46	49	53	56	5
20	13	16	20	24	27	31	34	38	42	45	49	53	56	60	6
21		18	22	26	29	33	37	41	45	48	52	56	60	63	6
22		20	24	28	32	36	39	43	47	51	55	59	63	67	7
23			26	30	34	38	42	46	50	55	59	63	67	71	
24			28	32	36	41	45	49	53	58	62	66	71	75	
25				34	39	43	48	52	57	61	66	70	75	79	
26				36	41	46	50	55	60	65	69	74	79	83	
27					44	49	53	58	63	68	73	78	83	87	
28					46	51	56	61	67	72	77	82	87	92	
29						54	59	65	70	75	80	86	91	96	1
30						57	63	68	73	79	84	90	95	101	1
31							66	71	77	83	88	94	99	105	1
32							69	75	81	86	92	98	104	110	1
33								79	84	90	96	102	108	114	1
34								82	88	94	101	107	113	119	1
35									92	98	105	111	117	124	1
36									96	103	109	116	122	129	1

From table 16, the cordwood estimates for the two sample junipers are 10 and 8 lb/ft. The second juniper has two stems at breast height, so the second column in the table is used. The estimated juniper cordwood on the sample transect is:

$$\frac{43{,}560\ \text{ft}^2/\text{acre}}{100\ \text{ft}} \times (10 + 8)\text{lb/ft} = 7{,}841\ \text{lb/acre}$$

Dividing this estimate by 24 lb/ft^3 (the specific weight of juniper cordwood) converts the estimate to 327 ft^3/acre. Total estimated cordwood for the example transect is 17,424 lb/acre or 657 ft^3/acre.

From table 17, the slash estimates for the three sample pinyons are 7, 22, and 12 lb/ft. From table 18, the slash estimates for the two junipers are both 20 lb/ft. The estimated slash for the sample transect is:

$$435.6\ \text{ft/acre} \times (7 + 22 + 12 + 20 + 20)\ \text{lb/ft} = 35{,}284\ \text{lb/acre}$$

Table 16.--*Juniper wood in pounds per foot of average crown diameter*

D.b.h.	Number of stems											
	1	2	3	4	5	6	7	8	9	10	11	12
Inches												
4	3											
5	3	3										
6	4	4	3									
7	6	5	4	4	3							
8	7	7	6	5	5	4						
9	9	8	7	6	6	5	5	5				
10	10	10	9	8	7	7	6	6	5	5		
11	12	12	11	10	9	8	8	7	7	7	6	
12	14	14	12	11	11	10	9	9	9	8	8	8
13	17	16	15	14	13	12	11	11	10	10	10	9
14	19	18	17	16	15	14	13	13	12	12	12	11
15	22	21	20	18	17	16	16	15	15	14	14	13
16	25	24	22	21	20	19	18	18	17	17	16	16
17	28	27	25	24	23	22	21	20	20	19	19	18
18	31	30	28	27	26	25	24	23	22	22	21	21
19	35	34	32	30	29	28	27	26	25	25	24	24
20	38	37	35	33	32	31	30	29	29	28	27	27
21	42	41	39	37	35	34	33	33	32	31	31	30
22	46	45	43	41	39	38	37	36	35	35	34	34
23	50	49	47	45	43	42	41	40	39	38	38	37
24	55	53	51	49	47	46	45	44	43	42	42	41

Table 17.--*Pinyon slash in pounds per foot of average crown diameter*

Stump diameter	Slash	Stump diameter	Slash
Inches	*Pounds per foot*	*Inches*	*Pounds per foot*
6	7	22	37
7	10	23	38
8	12	24	39
9	15	25	40
10	17	26	41
11	20	27	41
12	22	28	42
13	24	29	42
14	26	30	42
15	28	31	42
16	29	32	43
17	31	33	42
18	32	34	42
19	34	35	42
20	35	36	42
21	36		

Table 18.--*Juniper slash in pounds per foot of average crown diameter*

D.b.h.	Crown diameter (feet)												
	8	10	12	14	16	18	20	22	24	26	28	30	32
Inches	- *Pounds per foot* -												
4	7	9	11	13	15	16	18						
5	9	10	12	14	15	17	18						
6	10	12	13	15	16	18	19	20					
7	12	13	14	16	17	19	20	21					
8	14	14	15	17	18	19	20	21	22				
9	16	16	16	18	19	20	21	22	23				
10	17	17	18	19	20	21	22	23	23	24			
11	19	18	19	20	21	22	22	23	24	24			
12	21	20	20	21	21	22	23	24	24	25	25		
13		21	21	22	22	23	24	24	25	25	25		
14		22	22	22	23	24	24	25	25	26	26	26	
15			23	23	24	25	25	26	26	26	26	26	
16			24	24	25	25	26	26	27	27	27	27	26
17				25	26	26	26	27	27	27	27	27	27
18				26	26	27	27	28	28	28	28	28	27
19					27	28	28	28	28	28	28	28	27
20					28	28	29	29	29	29	29	28	28
21						29	29	29	29	29	29	29	28
22						30	30	30	30	30	30	29	29
23							31	31	31	30	30	30	29
24							31	31	31	31	31	30	30

Aboveground Biomass

Estimates of aboveground biomass per foot of crown diameter of pinyon are in table 19. Estimates for juniper are in table 20. These estimates were calculated from the regression equations in table 14.

Continuing with the example, the estimated ratios for the three sample pinyons are 11, 34, and 19 lb/ft. The estimated aboveground biomass of pinyon on the transect is:

$$\frac{k}{L} \sum^{n} (\hat{\frac{M}{C}})_i = \frac{43{,}560 \text{ ft}^2/\text{acre}}{100 \text{ ft}} \times (11 + 34 + 19) \text{ lb/ft} = 27{,}878 \text{ lb/acre}$$

The estimated ratios for the two sample junipers are 29 and 28 lb/ft. The estimated aboveground biomass of juniper on the transect is:

$$435.6 \text{ ft/acre} \times (29 + 28) \text{ lb/ft} = 24{,}829 \text{ lb/acre}$$

Estimated aboveground biomass on the transect is 52,707 lb/acre or 26 tons/acre. Aboveground biomass can also be estimated by adding the estimates of cordwood and slash together. The direct estimates are slightly more precise than the summed estimates of cordwood and slash.

Table 19.--*Pinyon aboveground biomass in pounds per foot of average crown diameter*

Stump	Height (feet)														
diameter	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
Inches	- - - - - - -						*Pounds per foot*		- - - - - - -						
6	8	9	11	12	13	15	16	18	19						
7	11	12	14	15	17	19	20	22	23						
8	13	15	17	19	20	22	24	26	28	29					
9	16	18	20	22	24	26	28	30	32	34					
10	18	20	23	25	27	29	32	34	36	38	41				
11	21	23	26	28	30	33	35	38	40	43	45				
12	23	26	28	31	34	36	39	42	44	47	50	53			
13	26	28	31	34	37	40	43	46	49	52	54	57			
14	28	31	34	37	40	44	47	50	53	56	59	62	65		
15	31	34	37	40	44	47	50	54	57	60	63	67	70		
16	33	36	40	43	47	50	54	61	64	68	71	75	78		
17	35	39	43	46	50	54	58	61	65	69	72	76	80	83	
18	38	42	46	49	53	57	61	65	69	73	77	81	84	88	97
19	40	44	48	52	57	61	65	69	73	77	81	85	89	93	97
20	43	47	51	55	60	64	68	73	77	81	85	90	94	98	102
21		49	54	58	63	67	72	76	81	85	90	94	99	103	107
22		52	57	61	66	71	75	80	85	89	94	98	103	108	112
23			59	64	69	74	79	84	88	93	98	103	108	113	117
24			62	67	72	77	82	87	92	97	102	107	112	117	122
25				70	75	80	86	91	96	101	106	112	117	122	127
26				73	78	84	89	94	100	105	110	116	121	127	132
27					81	87	92	98	103	109	114	120	126	131	137
28					84	90	96	101	107	113	118	124	130	136	141
29						93	99	105	111	117	122	128	134	140	146
30						96	102	108	114	120	126	132	139	145	151
31							105	112	118	124	130	137	143	149	155
32							109	115	121	128	134	141	147	153	160
33								118	125	131	138	145	151	158	164
34								122	128	135	142	149	155	162	169
35									132	139	146	152	159	166	173
36									135	142	149	156	163	170	177

Table 20.--*Juniper aboveground biomass in pounds per foot of average crown diameter*

D.b.h.	Crown diameter (feet) 8	10	12	14	16	18	20	22	24	26	28	30	32
Inches						*Pounds per foot*							
4	10	11	13	14	15	16	18						
5	12	14	15	16	17	19	20						
6	14	16	17	18	20	21	22	24					
7	17	18	19	21	22	23	25	26					
8	19	20	22	23	24	26	27	28	30				
9	21	23	24	25	27	28	29	31	32				
10	24	25	26	28	29	30	32	33	34	36			
11	26	27	29	30	31	33	34	35	37	38			
12	28	30	31	32	34	35	36	38	39	40	41		
13		32	33	35	36	37	39	40	41	42	44		
14		34	36	37	38	40	41	42	43	45	46	47	
15			38	39	40	42	43	44	46	47	48	50	
16			40	41	43	44	45	47	48	49	51	52	5
17				44	45	46	48	49	50	52	53	54	5
18				46	47	49	50	51	53	54	55	57	5
19					50	51	52	54	55	56	58	59	6
20					52	53	55	56	57	59	60	61	6
21						56	57	58	60	61	62	64	6
22						58	59	61	62	63	65	66	6
23							62	63	64	65	67	68	6
24							64	65	66	68	69	70	7

Foliage and Fine Fuels

Regression equations for estimating ratios of foliage and fine fuels to crown diameter hav the same input variables as the regression equations for slash (tables 13 and 14). Since no tables for foliage and fine fuels are included in this paper, the following estimates were calculated directly from the regression equations in table 14. In actual practice, the user would either prepare the tables or program the equations for evaluation by computer or programable calculator.

The estimated ratios of fine fuels to crown diameter of the three sample pinyons are 4, 1 and 6 lb/ft. For the two sample junipers, the estimates are both 10 lb/ft. The estimated fin fuels at the sample transect are:

$$\frac{k}{L}\sum^{n}\left(\frac{\widehat{FF}}{C}\right)_i = \frac{43{,}560\ \text{ft}^2/\text{acre}}{100\ \text{ft}} \times (4 + 10 + 6 + 10 + 10)\ \text{lb/ft} = 17{,}424\ \text{lb/acre}$$

The estimated ratios of foliage to crown diameter of the three sample pinyons are 3, 6, a 4 lb/ft. The estimates for the two sample junipers are both 8 lb/ft. The estimated foliage a the sample transect is:

$$435.6\ \text{ft/acre} \times (3 + 6 + 4 + 8 + 8) = 12{,}632\ \text{lb/acre}$$

Canopy Cover

The calculation of canopy cover percentage from line-intersect data is simple, but its theoretical basis can be difficult to grasp. The estimate is the sum of the ratios of crown area to crown diameter $(\frac{Ca}{C})_i$ of the intersecting trees divided by the transect length (L) and multiplied by 100 percent:

$$\text{Cover \% (line estimate)} = \frac{100\%}{L} \sum^{n} \left(\frac{Ca}{C}\right)_i$$

By substituting $\frac{\pi C^2}{4}$ for Ca, the equation is simplified to:

$$\text{Cover \% (line estimate)} = \frac{25\pi}{L} \sum^{n} C_i$$

in which L is transect length in meters or feet and C_i is the average crown diameter of each sampled tree in meters or feet. The estimated canopy cover percentage is directly proportional to the sum of the crown diameters of the sample trees on a transect. Estimated canopy cover at the example transect is:

$$\text{Cover \%} = \frac{25\pi}{100\text{ ft}} \times (10 + 14 + 12 + 16 + 18) = 55\%$$

Canopy cover by species can be calculated if desired. At the sample transect, the cover percentage is 28 percent pinyon and 27 percent juniper.

The equation for average canopy cover in a stand is:

$$\text{Cover \% (stand estimate)} = \frac{25\pi}{L \cdot N} \sum^{N} \sum^{n} C_i$$

Trees per Unit Area

Estimated tree density is proportional to the sum of the reciprocals of the crown diameters f the sample trees on a transect:

$$\text{Tree density (line estimate)} = \frac{k}{L} \sum^{n} \frac{1}{C_i}$$

On the sample transect, the estimated tree density is:

$$\text{Tree density} = \frac{43{,}560}{100} \times \left(\frac{1}{10} + \frac{1}{14} + \frac{1}{12} + \frac{1}{16} + \frac{1}{18}\right) = 162 \text{ trees/acre}$$

Tree density can be calculated by species and even by size classes, if desired.

Stand Basal Area

The generalized equation for calculating stand basal area from line-intersect data is:

$$\text{Stand basal area (line estimate)} = \frac{k}{L} \sum^{n} \left(\frac{B}{C}\right)_i$$

in which stand basal area is in m^2/ha or ft^2/acre, k is 10 000 m^2/ha or 43,560 ft^2/acre, L is transect length in meters or feet, and $(\frac{B}{C})$ is the ratio of tree basal area (m^2 or ft^2) to averag crown diameter (m or ft) of each intersected tree.

After substituting $\frac{\pi Ds^2}{4}$ for B and correcting for dimensional changes, the working equations are:

$$\text{Stand basal area } (m^2/ha) = \frac{\pi}{4L} \sum^{n} \left(\frac{Ds}{C}\right)_i$$

$$\text{Stand basal area } (ft^2/acre) = \frac{238}{L} \sum^{n} \left(\frac{Ds^2}{C}\right)_i$$

in which Ds is stump diameter in centimeters or inches and the basal area is at stump height.

Since we have chosen to take basal area at stump height and juniper stem diameter is measured more conveniently and precisely at breast height, we developed regression equations to estimate the ratio of stump basal area to crown diameter of juniper:

$$\widehat{\left(\frac{B}{C}\right)} = 34.62 + 6.553Db \qquad \{\text{metric}\}$$

$$\widehat{\left(\frac{B}{C}\right)} = 1.636 + 0.7864Db \qquad \{\text{U.S.}\}$$

in which $\widehat{(\frac{B}{C})}$ is the ratio of basal area to crown diameter in cm^2/m or $inches^2$/ft and Db is the diameter breast height in centimeters or inches. These equations are based on the same data s t as the biomass equations. The R^2 is 0.882 and the CVR is 23.0 percent.

Substituting these equations for $\frac{B}{C}$ in the generalized equation and correcting for dimens ns produces these working equations for juniper:

$$\text{Stand basal area } (m^2/ha) = \frac{34.6}{L}n + \frac{6.55}{L} \sum^{n} Db_i$$

$$\text{Stand basal area } (ft^2/acre) = \frac{495}{L}n + \frac{238}{L} \sum^{n} Db_i$$

At the example transect, estimated basal area of pinyon is:

$$\frac{238}{L} \sum^{n} \left(\frac{Ds^2}{C}\right)_i = \frac{238}{100} \times \left(\frac{6^2}{10} + \frac{12^2}{14} + \frac{8^2}{12}\right) = 46 \text{ ft}^2/\text{acre}$$

and the estimated basal area of juniper is:

$$\frac{495}{L}n + \frac{238}{L} \sum^{n} Db_i = \frac{495}{100} \times 2 + \frac{238}{100} \times (10 + 9) = 55 \text{ ft}^2/\text{acre}$$

Total estimated stand basal area at the transect is 101 ft^2/acre.

Growth Rates

The general equation for calculating estimated stand basal area growth from line intersect data is:

$$\frac{\Delta B}{A} = \frac{k}{L} \sum^{n} \left(\frac{\Delta B}{C}\right)_i$$

$\frac{\Delta B}{A}$ is basal area growth (m /ha/decade or ft /acre/decade) and $\left(\frac{\Delta B}{C}\right)_i$ is the ratio of basal area growth of each sampled tree to its crown diameter (m^2/decade/m or ft^2/decade/ft). The equation simplies to:

$$\frac{\Delta B}{A} = \frac{1}{L} \sum^{n} \left(\frac{\Delta B}{C}\right)_i \qquad \{\text{metric}\}$$

if $\left(\frac{\Delta B}{C}\right)_i$ is expressed in cm^2/decade/m. The U.S. equivalent, if $\left(\frac{\Delta B}{C}\right)_i$ is expressed in inches^2/decade/ft, is:

$$\frac{\Delta B}{A} = \frac{302.5}{L} \sum^{n} \left(\frac{\Delta B}{C}\right)_i \qquad \{\text{U.S.}\}$$

The equation for calculating estimated biomass growth is:

$$\frac{\Delta M}{A} = \frac{k}{L} \sum^{n} \left(\frac{\Delta M}{C}\right)_i$$

$\frac{\Delta M}{A}$ is biomass growth (kg/hectare/decade or lb/acre/decade) and $\left(\frac{\Delta M}{C}\right)_i$ is the ratio of biomass growth of each sampled tree to its crown diameter (kg/decade/meter or lb/decade/ft).

Equations for estimating $\left(\frac{\Delta B}{C}\right)_i$ and $\left(\frac{\Delta M}{C}\right)_i$ in terms of aboveground biomass and cordwood are set forth in table 21. These regression equations were developed in the same manner as the growth equations for point sampling (table 11) and use the same set of input variables. Most of these equations have more than two input variables and cannot be presented satisfactorily in abular form. They can be evaluated more efficiently by computer or programable calculator.

Two equations for pinyon basal area growth are included in table 21. The first is very recise (*CVR* = 4.4 percent), but the second is reasonably precise (*CVR* = 18.5 percent), easier o use, requires no measurements of crown diameter, and can be presented as a table (table 22).

In the following calculations of growth on the example transect, the regression estimates ere calculated directly from the equations in table 21, using the sample data presented in the ntroductory section on line-intersect sampling. Estimated pinyon basal area growth is:

$$\frac{302.5}{L} \sum^{n} \left(\frac{\Delta B}{C}\right)_i = \frac{302.5}{100} \times (0.73 + 1.53 + 0.94) = 9.98 \text{ ft}^2\text{/acre/decade}$$

Table 21.--*Regression equations for estimating basal area, aboveground biomass, and cordwood grow rates of pinyon and juniper trees. The dependent variable* (Y) *is decadal growth divid by average crown diameter. The independent variables are as defined in table 11 excep* Z, *which is* (H•Ds•Rs/1,000)

Equations	$\bar{Y}$	SDR	CVR	R^2
			Percent	
Metric				
Pinyon basal area growth/crown diameter	(cm^2/decade/m)			
$\hat{Y} = 3.980\frac{Rs\cdot Ds}{C} - 4.349\frac{Rs^2}{C} - 0.4554Rs^2 - 0.02916Rs\cdot Ds - 0.318$	30.67	1.35	4.40	0.995
$\hat{Y} = 11.12Rs + 1.517Rs^2 + 0.1543Rs\cdot Ds + 5.45$	30.67	5.67	18.5	.907
Pinyon total aboveground biomass growth/crown diameter	(kg/decade/m)			
$\hat{Y} = 14.07Z^{\frac{1}{2}} + 1.125Rs + 0.6325H\cdot Rs - 1.70$	12.17	1.98	16.3	.928
Pinyon cordwood growth/crown diameter	(kg/decade/m)			
$\hat{Y} = 28.90Z - 9.385Z^2 - 2.153Rs + 2.24$	6.51	1.69	25.9	.902
Juniper basal area growth/crown diameter	(cm^2/decade/m)			
$\hat{Y} = 2.991\frac{Db\cdot Rb}{C} + 17.22Rb - 1.872Rb^2 + 0.19$	31.20	4.92	15.8	.939
Juniper total aboveground biomass growth/crown diameter	(kg/decade/m)			
$\hat{Y} = 3.650Rb + 0.5363C\cdot Rb + 0.548$	7.66	1.79	23.4	.861
Juniper cordwood growth/crown diameter	(kg/decade/m)			
$\hat{Y} = 0.04466Db\cdot Rb + 0.06524Db\cdot Rb\cdot Sb^{-\frac{1}{2}} + 0.32$	2.51	0.423	25.1	.866
U.S.				
Pinyon basal area growth/crown diameter	(in^2/decade/ft)			
$\hat{Y} = 3.980\frac{Rs\cdot Ds}{C} - 4.349\frac{Rs^2}{C} - 0.1388Rs^2 - 0.00889Rs\cdot Ds - 0.015$	1.449	.064	4.40	.995
$\hat{Y} = 1.334Rs + 0.4624Rs^2 + 0.0470Rs\cdot Ds + 0.257$	1.449	.268	18.5	.907
Pinyon total aboveground biomass growth/crown diameter	(lb/decade/ft)			
$\hat{Y} = 13.26Z^{\frac{1}{2}} + 1.920Rs + 0.3291H\cdot Rs - 1.140$	8.18	1.33	16.3	.928
Pinyon cordwood growth/crown diameter	(lb/decade/ft)			
$\hat{Y} = 38.19Z - 24.39Z^2 - 3.675Rs + 1.504$	4.37	1.14	25.9	.902
Juniper basal area growth/crown diameter	(in^2/decade/ft)			
$\hat{Y} = 2.991\frac{Db\cdot Rb}{C} + 2.066Rb - 0.5706Rb^2 + 0.009$	1.474	0.232	15.8	.939
Juniper total aboveground biomass growth/crown diameter	(lb/decade/ft)			
$\hat{Y} = 6.230Rb + 0.2790C\cdot Rb + 0.368$	5.15	1.20	23.4	.861
Juniper cordwood growth/crown diameter	(lb/decade/ft)			
$\hat{Y} = 0.1936Db\cdot Rb + 0.2828Db\cdot Rb\cdot Sb^{-\frac{1}{2}} + 0.215$	1.69	0.423	25.1	.866

able 22.--*Ratio of decadal basal area growth to average crown diameter as a function of decadal radial wood growth* (Rs) *and stump diameter of pinyon*

Rs	Stump diameter (inches) 8	12	16	20	24	28	32	36
nches	*Square inches per decade per foot*							
0.10	0.43	0.45	0.47	0.49	0.51	0.53	0.55	0.56
.15	.52	.55	.58	.61	.64	.66	.69	.72
.20	.62	.66	.69	.73	.77	.81	.84	.88
.25	.71	.76	.81	.85	.90	.95	1.00	1.04
.30	.81	.87	.92	.98	1.04	1.09	1.15	1.21
.35	.91	.98	1.04	1.11	1.18	1.24	1.31	1.37
.40	1.01	1.09	1.17	1.24	1.32	1.39	1.47	1.54
.45	1.12	1.20	1.29	1.37	1.46	1.54	1.63	1.71
.50	1.23	1.32	1.42	1.51	1.60	1.70	1.79	1.89
.55	1.34	1.44	1.54	1.65	1.75	1.85	1.96	2.06
.60	1.45	1.56	1.68	1.79	1.90	2.01	2.13	2.24
.65	1.56	1.69	1.81	1.93	2.05	2.17	2.30	2.42
.70	1.68	1.81	1.94	2.08	2.21	2.34	2.47	2.60
.75	1.80	1.94	2.08	2.22	2.36	2.50	2.65	2.79
.80	1.92	2.07	2.22	2.37	2.52	2.67	2.82	2.97
.85	2.04	2.20	2.36	2.52	2.68	2.84	3.00	3.16
.90	2.17	2.34	2.51	2.68	2.85	3.02	3.19	3.35
.95	2.30	2.48	2.66	2.83	3.01	3.19	3.37	3.55
.00	2.43	2.62	2.81	2.99	3.18	3.37	3.56	3.75
.05	2.56	2.76	2.96	3.15	3.35	3.55	3.75	3.94
.10	2.70	2.90	3.11	3.32	3.52	3.73	3.94	4.15
.15	2.84	3.05	3.27	3.48	3.70	3.92	4.13	4.35
.20	2.97	3.20	3.43	3.65	3.88	4.10	4.33	4.55

The first juniper (tree no. 4) has a breast height diameter of 10 inches, an average crown iameter of 16 ft, and the average combined width (*Rb*) of the last 10 complete annual rings is .40 inches. Its basal area growth, according to the juniper basal area equation in table 21, s 1.49 inches^2/decade/ft of crown diameter. The second juniper has two stems at breast height, and 7 inches in diameter, that are equivalent to a single stem 9 inches in diameter. Cores ken at breast height on the larger stem show a radial wood growth rate (Rb_1) of 0.35 inches r decade. This is corrected to an equivalent growth rate by:

$$Rb = \frac{Rb_1}{Db_1} \times \sqrt{Db_1^2 + Db_2^2 + \ldots Db_n^2} = \frac{0.35}{7} \times 9 = 0.45 \text{ inch/decade.}$$

The estimated basal area growth of the second juniper is 1.50 inches^2/decade/ft of crown ameter. Estimated juniper basal area growth at stump height is:

$$\frac{302.5}{100} \times (1.49 + 1.50) = 9.04 \text{ ft}^2\text{/acre/decade}$$

Combined estimated basal area growth on the example transect is 19.0 ft^2/acre/decade.

Estimated biomass growth rates on the sample transect are:

Pinyon total: $435.6 \times (3.81 + 7.70 + 5.18) = 7{,}270$ lb/acre/decade
Juniper total: $435.6 \times (4.65 + 5.43) = 4{,}391$ lb/acre/decade
Pinyon cordwood: $435.6 \times (1.47 + 3.90 + 2.15) = 3{,}276$ lb/acre/decade
Juniper cordwood: $435.6 \times (2.12 + 1.81) = 1{,}712$ lb/acre/decade.

In cubic volume, the estimated cordwood growth rate of pinyon and juniper combined is:

$$\frac{3{,}276 \text{ lb/acre}}{29 \text{ lb/ft}^3} + \frac{1{,}712 \text{ lb/acre}}{24 \text{ lb/ft}^3} = 184 \text{ ft}^3\text{/acre/decade}$$

The line-intersect method described here is theoretically correct only if the tree crowns are perfectly round. Irregular crowns introduce error. The mean error due to irregular crown shape is probably negligible except in stands where the maximum crown axes tend to be oriented in the same direction. In such stands, the bias can be reduced by laying out one-half of the lines perpendicular to the other half. In stands with very irregular crown shapes, the point method should be used if feasible.

DISCUSSION

The procedures apply to simple situations as well as the more complex. For example, to estimate the pinyon cordwood volume in a stand, it is only necessary to lay out a few transect lines and determine the heights and stump diameters of the intersected pinyon trees. The cordwood volume is estimated with a few simple calculations using table 15. The amount of slash that would be produced could also be estimated by using the stump diameter data and table 16. If an angle gage can be used, the procedure would involve determining crown diameters and heights of the trees tallied at the sampling points and using table 5 to calculate the estimatd cordwood volume.

The biomass estimation tables are intended for the simpler sampling situations. For more complex or extensive inventories, computers or programable calculators should be programed to evaluate the regression equations and compute the estimates. Appendix B contains input and ouput data that could be used to verify programs.

Actual measurement of most of the input variables is usually not necessary for the experenced cruiser. Average crown diameter, stem diameter, and height can be estimated satisfactorily after adequate training and practice.

Decadal radial wood growth must be determined more precisely. One increment core is usually adequate on small trees with reasonably round stems. If the tree is on a slope, the core should be taken along the contour, rather than from the uphill or downhill side of the tree. Two cores should be taken from opposite sides of the stem on medium size trees with fairly round stems. Four cores should be taken (about 90° apart) from large trees and trees with badly out-of-round stems. The cores should be taken at stump height (15 cm or 6 inches) on pinyon and at breast height (137 cm or 54 inches) on junipers. The width of the 10 outermost complete rings on each core should be measured to the nearest 1 mm (or 1/20 inch) under a 7- or 10-power microscope. If more than one core is taken from a tree, the measured widths are averaged to obtain R_s or R_b.

The procedures and regression equations in this paper were developed specifically for singleleaf pinyon and for Utah juniper within the geographical range of singleleaf pinyon. The sampling procedures, however, are readily adaptable to other woodland species although th regression equations do not apply directly.

There are a number of ways to adapt these procedures to other species. One way is to develop new regression equations, similar to the ones in this paper, for the species to be sampled. Another, more rapid, way is to use the procedures and equations in this paper on similar species and apply correction factors.

For example, Colorado pinyon (*Pinus edulis*) could be sampled using the point or line-intersect procedures described for singleleaf pinyon if a subsample of the sample trees were selected for actual measurement of the attribute being inventoried. Specifically, if cordwood volume of Colorado pinyon were being inventoried, the following procedure could be used. The pounds per acre of cordwood would be estimated using the singleleaf pinyon equations and sampling methods (either point or line-intersect). In addition, the actual cubic foot volume of cordwood would be measured by dendrometer or by other means in a subsample of the selected trees (every 20th sample tree, perhaps).

If the point sampling method is used, the correction factor (*Cf*) would be:

$$Cf = \sum^{n} \frac{V_i}{B_i} \bigg/ \sum^{n} \left(\frac{\hat{W}}{B}\right)_i$$

in which V_i is the actual volume (ft^2) of each subsampled tree, B_i is the basal area (ft^2) of that tree, and $(\frac{\hat{W}}{B})_i$ is the tree's estimated pounds of cordwood per square foot of basal area from table 5 or the cordwood equation in table 2.

If the line intercept method is used, the correction factor is:

$$Cf = \sum^{n} \frac{V_i}{C_i} \bigg/ \sum^{n} \left(\frac{\hat{M}}{C}\right)_i$$

in which C_i is the average crown diameter of the subsampled tree with volume V_i, and $(\frac{\hat{W}}{C})_i$ is he tree's estimated pounds of cordwood per foot average crown diameter from table 15 or the ordwood equation in table 11.

This correction factor serves the dual purpose of correcting for variations between single-eaf and Colorado pinyon and converting pounds to cubic feet. The corrected stand volume would e calculated by multiplying the stand estimate in pounds or pounds per acre by the correction actor.

The general approach would be the same in metric units or with other species. This approach ould also be used with singleleaf pinyon and Utah juniper to improve estimates by correcting or local variations.

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APPENDIX A

Sample Size and Sampling Error

For statistical purposes, the point estimates and line estimates can be treated in exactly the same way as estimates derived from fixed-size plots. The coefficient of variation ($C\%$) is calculated by dividing the standard deviation (s) of the individual point or line estimates by their mean ($\bar{x}$) and multiplying by 100.

$$C\% = \frac{s}{\bar{x}} \times 100$$

An estimate of the coefficient of variation is needed to determine the number of points or lines required to sample a stand within a chosen allowable sampling error percentage ($E\%$) of the expected mean. This estimate can be obtained from a preliminary survey or from previous experience in similar stands. The conventional equation for sample size (N) is:

$$N = \left(\frac{C\%}{E\%} \times t\right)^2$$

This equation requires iterative calculations because the value of "t" varies with the egrees of freedom that depend, in turn, on the value of N (Freese 1962). The following egression equation gives the same answers without iteration or the use of a "t" table:

$$N = a + b\left(\frac{C\%}{E\%}\right)^2$$

The regression coefficients (a and b) depend on the probability level chosen:

Probability level *Percent*	*a*	*b*
1	3.4	6.66
2	3.0	5.42
5	2.4	3.84
10	2.0	2.70
20	1.5	1.64
30	1.2	1.07
40	1.0	0.71
50	0.8	.46

These coefficients were calculated for each probability level by selecting five values of N and calculating values of $\left(\frac{C\%}{E\%}\right)^2$ that would yield precisely those values of N. For the 10 percent level of probability, the input data were:

(Y) N	$t_{0.10}$	(X) $\left(\frac{C\%}{E\%}\right)^2$
3	2.920	0.352
6	2.015	1.478
16	1.753	5.207
41	1.684	14.46
121	1.658	44.02

Simple linear regression of these data produced the coefficients given above for the 10 percent level of probability. The coefficients for the other probability levels were calculate with the same values of N and the appropriate values of t. The regression equations for all listed probability levels have an r^2 of at least 0.999 and will estimate N within one unit from $2<N<120$ or better.

For example, let us assume a 7-point (or line) survey of cordwood volume that yields the following point (or line) estimates: 650, 774, 867, 928, 1,023, 1,116, and 1,257 ft^3/acre. The mean value ($\bar{x}$) is 945 ft^3/acre and the standard deviation is 206 ft^3/acre.

$$C\% = \frac{s}{\bar{x}} \times 100 = \frac{206}{945} \times 100 = 21.8\%$$

If we choose the 10 percent level of probability, the sampling error is:

$$E\% = \frac{C\%}{\sqrt{N}} \times t_{.10} = \frac{21.8\%}{\sqrt{7}} \times 1.943 = 16.0\%$$

If we wish to reduce the sampling error to 10 percent, the number of samples required is:

$$N = a + b\left(\frac{C\%}{E\%}\right)^2 = 2 + 2.7 \left(\frac{21.8}{10}\right)^2 = 14.8$$

or, by the conventional equation:

$$N = \left(\frac{C\%}{E\%} \times t_{.10}\right)^2 = \left(\frac{21.8}{10} \times 1.761\right)^2 = 14.7$$

These results indicate that if there were no errors except those of sampling, the population mean would be within 16 percent of the sample mean (945 cubic feet per acre) unless a 1 in 10 chance had occurred, and that eight additional samples would reduce the sampling erro to less than 10 percent.

APPENDIX B

Data for Program Testing

This appendix provides check data for verifying computer programs. The input data are for n average size pinyon and an average size juniper. The output data are the estimated values btained from the respective regression equations using the input data. The data in metric units re not exactly equivalent to the data in U.S. units because of rounding.

SINGLELEAF PINYON

	Symbol	Metric		U.S.	
nput data					
tem diameter stump height (15 cm or 6 inches)	Ds	30.5	cm	12	in
rown diameter (average)	C	4.6	m	15	ft
ree height (total)	H	6.7	m	22	ft
dth of 10 annual rings (stump height)	Rs	1.22	cm	0.48	in
/Ds	X	0.040		0.040	
•Rs•H/1000	Z	0.2493		0.1267	
tput data					
oveground biomass/basal area	T/B	3,325	kg/m^2	678	lb/ft^2
rdwood/basal area	W/B	1,361	kg/m^2	278	lb/ft^2
Slash/basal area	S/B	2,007	kg/m^2	408	lb/ft^2
Fine fuels/basal area	FF/B	929	kg/m^2	189	lb/ft^2
Foliage/basal area	F/B	494	kg/m^2	100	lb/ft^2
Basal area growth/basal area	ΔB/B	1,814	cm^2/decade/m^2	0.181	ft^2/decade/ft^2
Aboveground biomass growth/basal area	ΔT/B	727	kg/decade/m^2	148	lb/decade/ft^2
Cordwood growth/basal area	ΔW/B	366	kg/decade/m^2	75	lb/decade/ft^2
Aboveground biomass/crown diameter	T/C	54.32	kg/m	36.49	lb/ft
Cordwood/crown diameter	W/C	22.49	kg/m	15.12	lb/ft
Slash/crown diameter	S/C	32.39	kg/m	21.74	lb/ft
Fine fuels/crown diameter	FF/C	14.50	kg/m	9.74	lb/ft
Foliage/crown diameter	F/C	8.40	kg/m	5.65	lb/ft
Basal area/crown diameter	B/C	159	cm^2/m	7.54	in^2/ft
Basal area growth/crown diameter	ΔB/C	28.7	cm^2/decade/m	1.36	in^2/decade/ft
Aboveground biomass growth/crown diameter	ΔT/C	11.87	kg/decade/m	7.98	lb/decade/ft
Cordwood growth/crown diameter	ΔW/C	6.23	kg/decade/m	4.19	lb/decade/ft

UTAH JUNIPER

	Symbol	Metric		U.S.	
Input Data					
Stem diameter breast height (137 cm or 4.5 ft)	Db	20	cm	8	in
Crown diameter (average)	C	4	m	13	ft
Width of 10 annual rings at breast height	Rb	1	cm	0.4	in
Number of stems at breast height	Sb	2		2	
Output data					
Aboveground biomass/crown area	T/CA	10.43	kg/m^2	2.172	lb/ft^2
Cordwood/crown area	W/CA	2.69	kg/m^2	0.573	lb/ft^2
Slash/crown area	S/CA	7.31	kg/m^2	1.515	lb/ft^2
Fine fuels/crown area	FF/CA	3.93	kg/m^2	0.817	lb/ft^2
Foliage/crown area	F/CA	3.13	kg/m^2	0.649	lb/ft^2
Basal area/crown area	B/CA	53.6	cm^2/m^2	239	ft^2/acre
Basal area growth/crown area	ΔB/CA	9.00	cm^2/decade/m^2	40.7	ft^2/decade/ace
Aboveground biomass growth/crown area	ΔT/CA	2.22	kg/decade/m^2	0.464	lb/decade/ft
Cordwood growth/crown area	ΔW/CA	0.686	kg/decade/m^2	0.147	lb/decade/ft
Aboveground biomass/crown diameter	T/C	33.01	kg/m	22.39	lb/ft
Cordwood/crown diameter	W/C	9.48	kg/m	6.55	lb/ft
Slash/crown diameter	S/C	23.75	kg/m	16.02	lb/ft
Fine fuels/crown diameter	FF/C	12.65	kg/m	8.54	lb/ft
Foliage/crown diameter	F/C	10.08	kg/m	6.83	lb/ft
Basal area/crown diameter	B/C	166	cm^2/m	7.93	in^2/ft
Basal area growth/crown diameter	ΔB/C	30.5	cm^2/decade/m	1.48	in^2/decade/f
Aboveground biomass growth/crown diameter	ΔT/C	6.34	kg/decade/m	4.31	lb/decade/ft
Cordwood growth/crown diameter	ΔW/C	2.14	kg/decade/m	1.47	lb/decade/ft

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Meeuwig, Richard O., and Jerry D. Budy.
1981. Point and line-intersect sampling in pinyon-juniper woodlands. USDA For. Serv. Gen. Tech. Rep. INT-104, 38 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Two probability proportional to size (p.p.s.) sampling methods have been adapted for use in pinyon-juniper woodlands. Procedures are described for estimating biomass, stand basal area, canopy cover, tree density, and growth rates using either point sampling or line-intersect sampling. Both sampling methods are supported by regression equations for estimating aboveground biomass, cordwood, slash, fine fuels, and foliage of singleleaf pinyon and Utah juniper. Regression equations for predicting decadal growth rates in terms of stand basal area, aboveground biomass, and cordwood are also presented.

KEYWORDS: pinyon, juniper, sampling methods, line-intersect, Bitterlich, inventory, growth

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The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

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**Intermountain
Forest and Range
Experiment Station**

General Technical
Report INT-105

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User's Manual: RID*POLY Geographic Information System

Wallace A. Deschene

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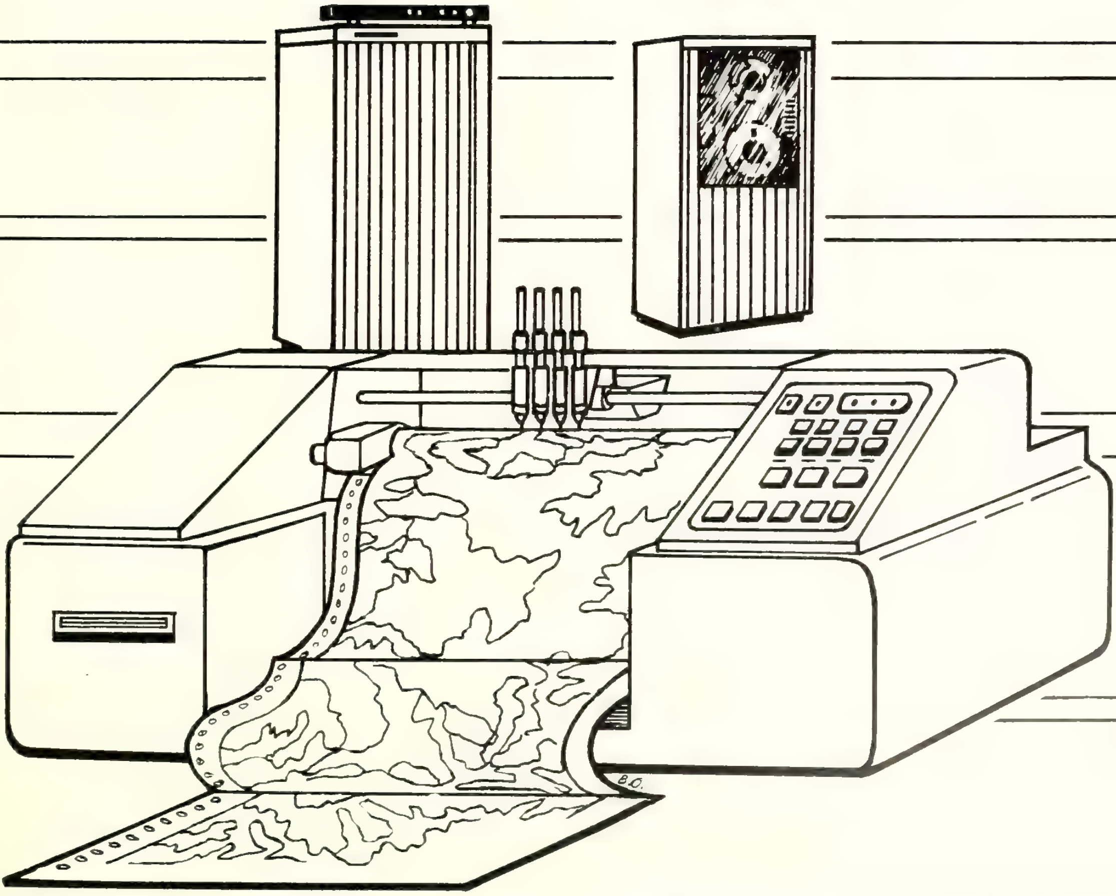

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United States
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Forest Service

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Forest and Range
Experiment Station**

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User's Manual: RID*POLY Geographic Information System

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Sections of this manual have been reproduced from the UNIVAC 1108 "Wildland Resource Information System: User's Guide" by Russell, Sharpnack, and Amidon.[1] More information on the development and characteristics of WRIS can be obtained from "WRIS: A Resource Information System for Wildland Management" by Russell, Sharpnack, and Amidon.[2]

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[1] Russell, Robert M., David A. Sharpnack, and Elliot L. Amidon. 1975. Wildland Resource Information System: user's guide. USDA For. Serv. Gen. Tech. Rep. PSW-10, 36 p. Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.

[2] Russell, Robert M., David A. Sharpnack, and Elliot L. Amidon. 1975. WRIS: a resource information system for wildland management. USDA For. Serv. Gen. Tech. Rep. PSW-107, 12 p. Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.

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0. FOREWORD

The RID*POLY program is the National Forest System version of the Wildland Resource Information System (WRIS) (Russell and others 1975). The RID*POLY program is the polygonal processor of the RID (Resources Infor-nation Display) System that stores and manipulates data attributed to geographical areas. The resource manager lefines an area by drawing a boundary around it on a map. In nature, such boundaries are irregular in shape. Their shapes are retained within the system by representing them mathematically as multiple-edged polygons. ''Polygons'' are the fundamental building blocks of RID*POLY. They can represent timber stands, management alternatives, soil ypes, and other entities. RID*POLY has been used primarily for timber management; therefore, examples and terminology in this report are from that discipline. Nevertheless, the system can be used for managing resources other han timber and in fields other than forestry.

A group of polygons forms a ''map.'' The collection of polygons must completely cover the surface area, but not verlap each other. All polygons on one map must be from the same ''layer'' representing one attribute, such as mber type. Other layers, which represent different attributes of the same geographical area, may be constructed. RID*POLY can overlay any two layers to deal with combinations of attributes.

The attribute of a polygon is expressed as a ''label,'' consisting of 1 to 36 characters. Each polygon must have a bel. A label does not have to be unique; it may occur many times on a map, once for every polygon containing the ame attribute. In addition, RID*POLY assigns each polygon a unique serial number called an ''item number,'' for urther identification.

RID*POLY can be used for an entire National Forest by digitizing each of the quadrangle maps needed to cover e forest and by processing the maps as separate units. Each layer is drawn on a separate map sheet. The map sheets e photographically reduced to enable the negatives to fit the dimensions of a densitometer bed or drum (maximum ze of 9 inches by 9 inches for SCANDIG).

The scanning operation stores the map on a magnetic tape file in either density or binary form. Density data are ocessed by a computer program (FREQTB), which prints a grid (binary map) that can be checked for error. The nary map consists of blanks and ones: blanks for the area between lines or background, and ones for the points falling on polygon boundary lines. Binary data are processed by a computer program (BIPRIN), which produces a binary ap and performs various editing procedures.

If a map is extremely simple—few boundary lines and most of the scanned points blank—it is more efficient to hand digitize and process it through the HANDY program than use FREQTB or BIPRIN.

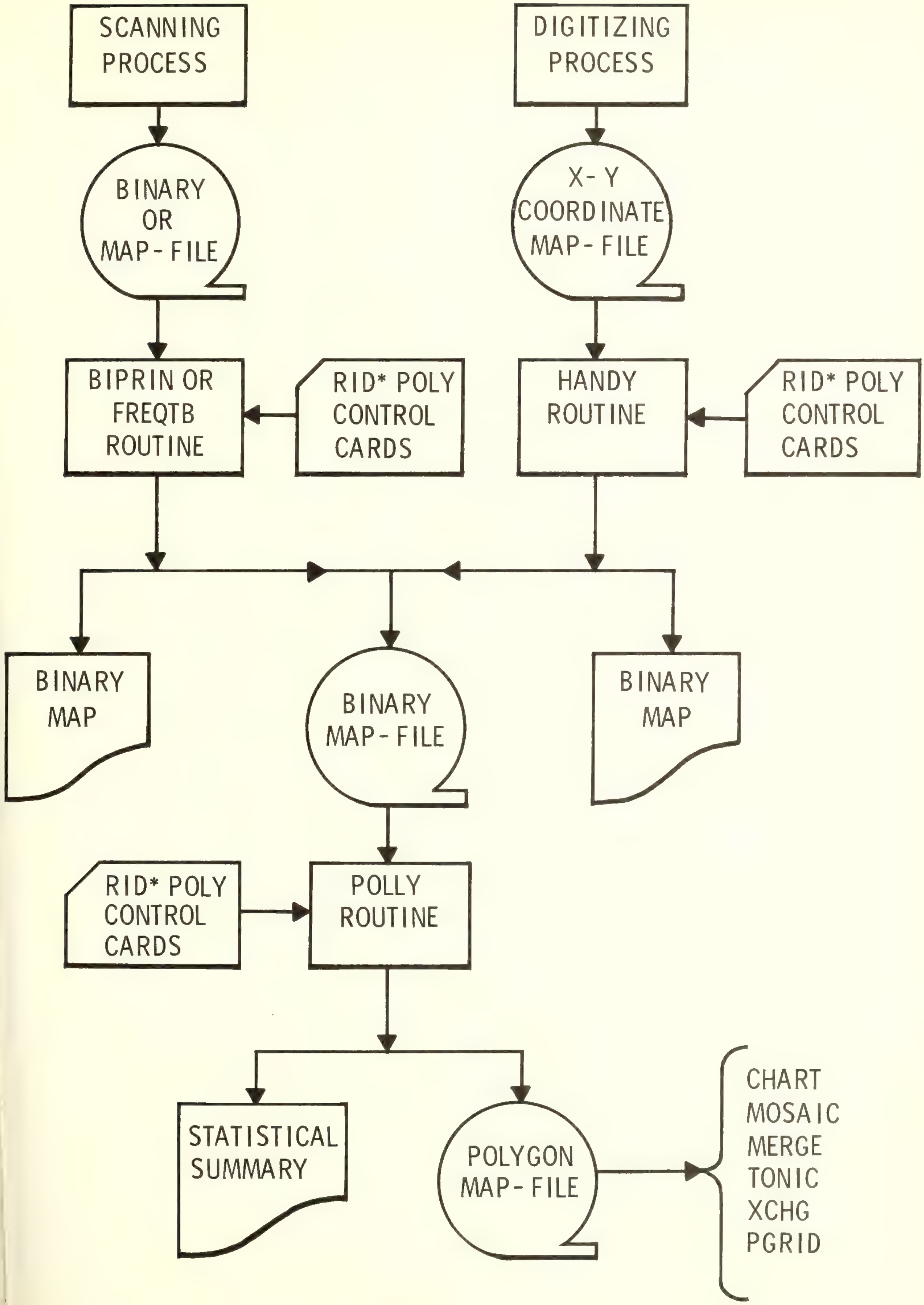
The POLLY program converts a binary map into a file of polygons, (called a polygon map file) and attaches a label to each. A complete data base is formed when the above process is performed for all maps required to cover a d ignated area.

Table 0.1.—Data recording devices and processing procedures

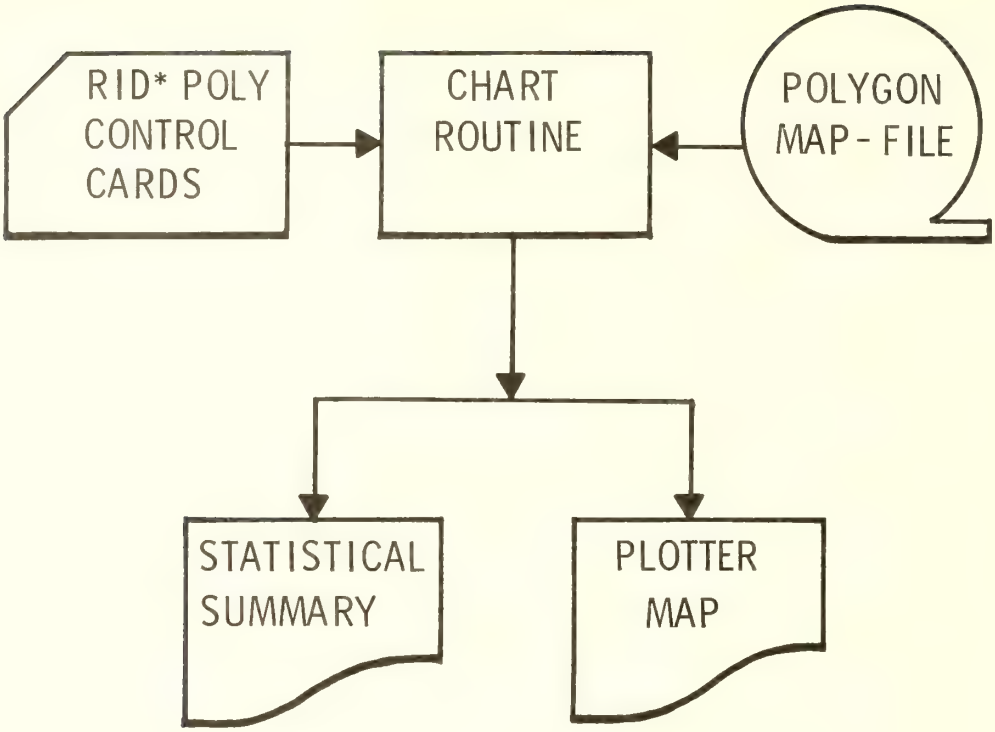
Data recording device	Output mode	Program processing sequence		
SCANDIG Scanner	BINARY OR		BIPRIN	POLLY
	DENSITY	FREQTB	BIPRIN	POLLY
PDS-1010 Scanner	DENSITY	FREQTB	BIPRIN	POLLY
PDS-1010A Scanner	DENSITY	FREQTB	BIPRIN	POLLY
NUMONICS 1224 Digitizer	X-Y COORDINATES	HANDY	BIPRIN	POLLY

The following sequence of steps describes the workflow required to process maps using the RID*POLY system (flow charts 0.1-0.7).

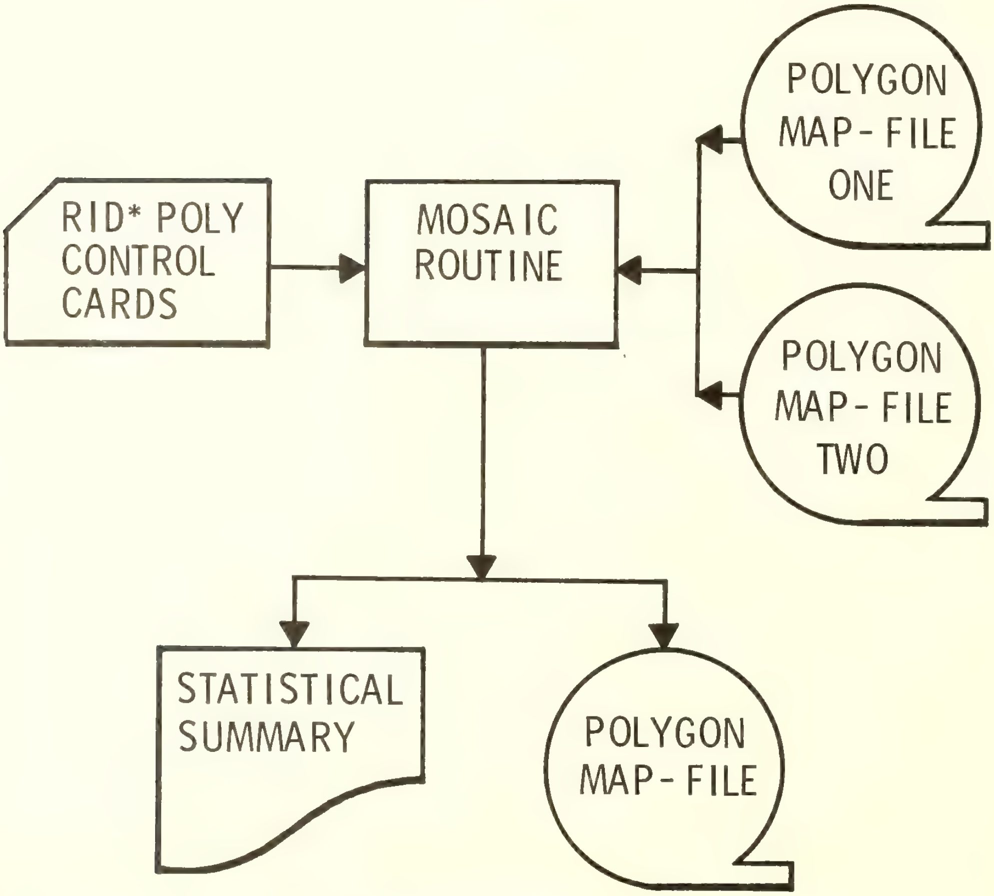
1. Record the labels (see section 5.2). Recording labels before any other work is done provides an additional close look at the maps and may uncover some remaining logical errors.
2. Produce and scan negative **or** digitize source map.
3. Convert input into a binary map-file, with BIPRIN for binary data (see section 4.2), FREQTB for density data (see section 4.1), or HANDY for digitizer data (see section 4.3).
4. Edit the binary map (see section 4.4). If the binary map requires many corrections, BIPRIN should be used to produce a permanent map containing the necessary corrections. Corrections made in a POLLY run are not recorded permanently and become expensive to process if POLLY is executed more than once per map.
5. Extract polygons from the binary map-file and produce a polygon map file with POLLY (see section 5.3). POLLY output should be edited and POLLY rerun until all error messages are eliminated (see section 5.4).
6. Once POLLY has been run without producing error messages, the polygon map-file can be processed by the following RID*POLY support programs:
   a. Plotter map can be produced with CHART (see section 6, flow chart 0.2). The plotted map can be used as an aid in editing polygon map-files or as a means of producing a final map product.
   b. Two map layers can be overlayed using the MOSAIC routine (see section 7, flow chart 0.3).
   c. Two polygon map-files can be combined using the MERGE routine (see section 8, flow chart 0.4).
   d. A polygon map-file can be updated using the TONIC routine (see section 9, flow chart 0.5).
   e. A polygon map-file can be converted into the Universal Data Exchange Format using the XCHG routine (see section 10, flow chart 0.6).
   f. A polygon map-file can be converted into a POLY*GRID file using PGRID (see section 11, flow chart 0.7).



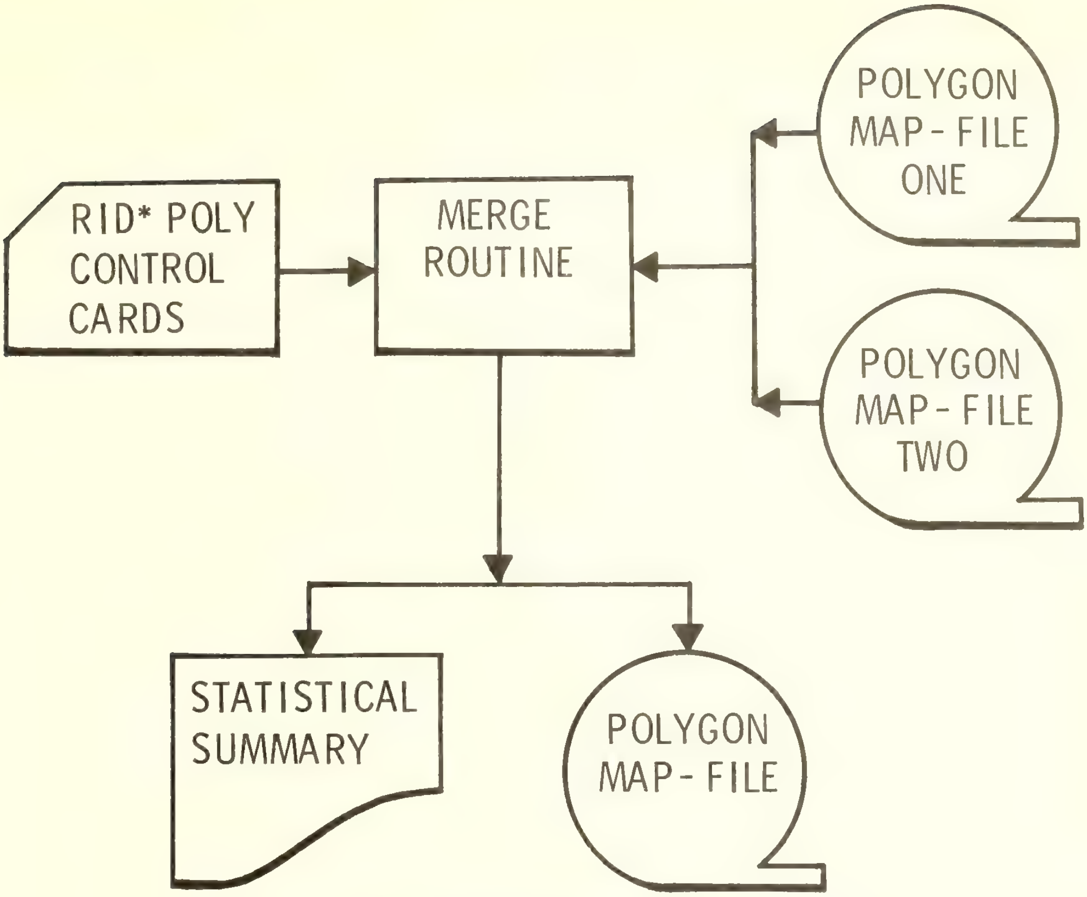
Flowchart 0.1.—Processing required to produce a polygon map-file.



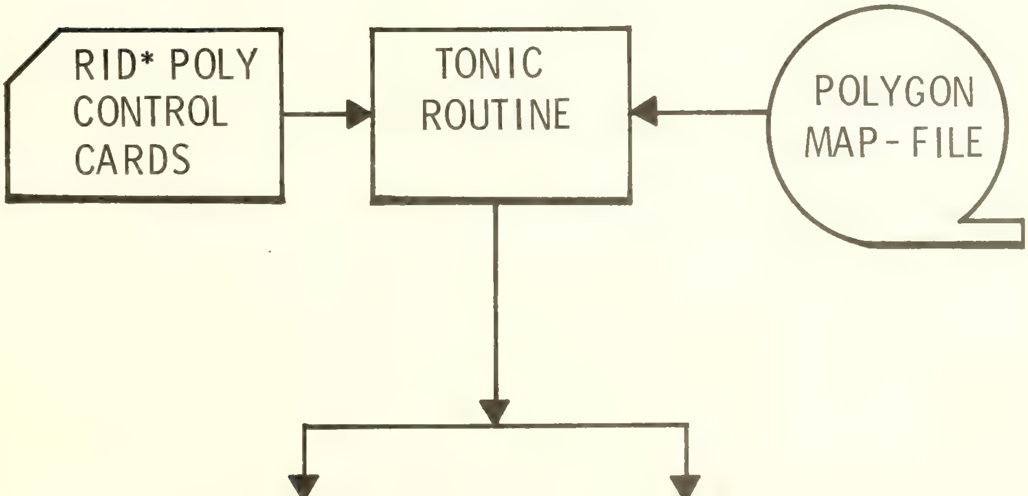
Flowchart 0.2.—Plotting a polygon map-file (CHART).



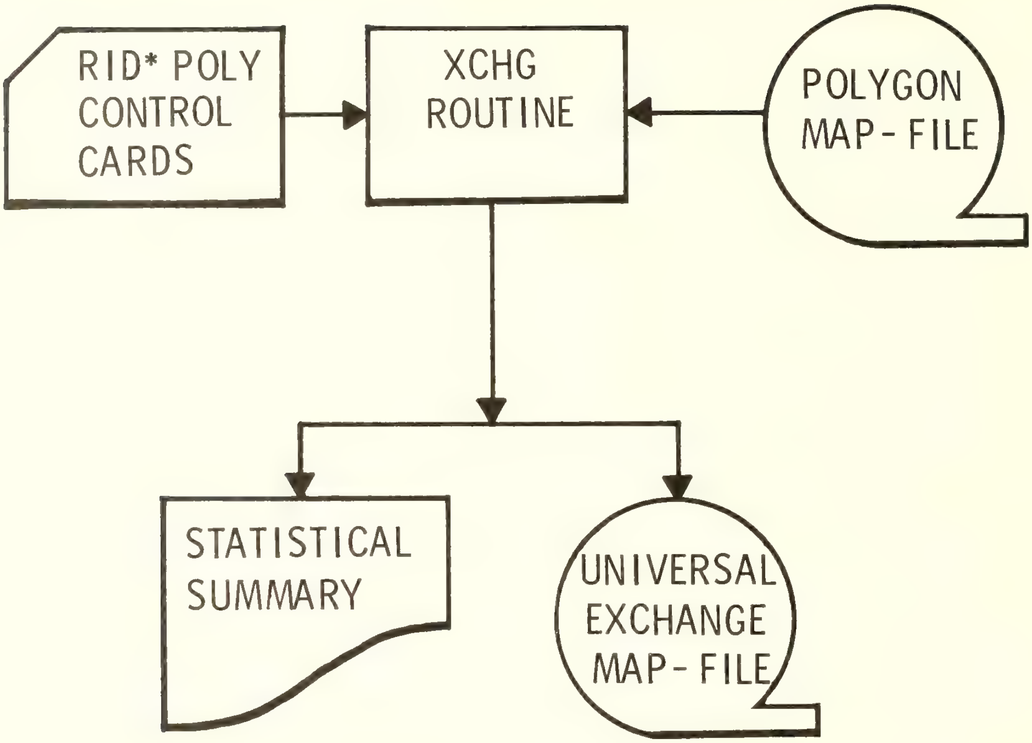
Flowchart 0.3.—Overlaying polygon map-files (MOSAIC).



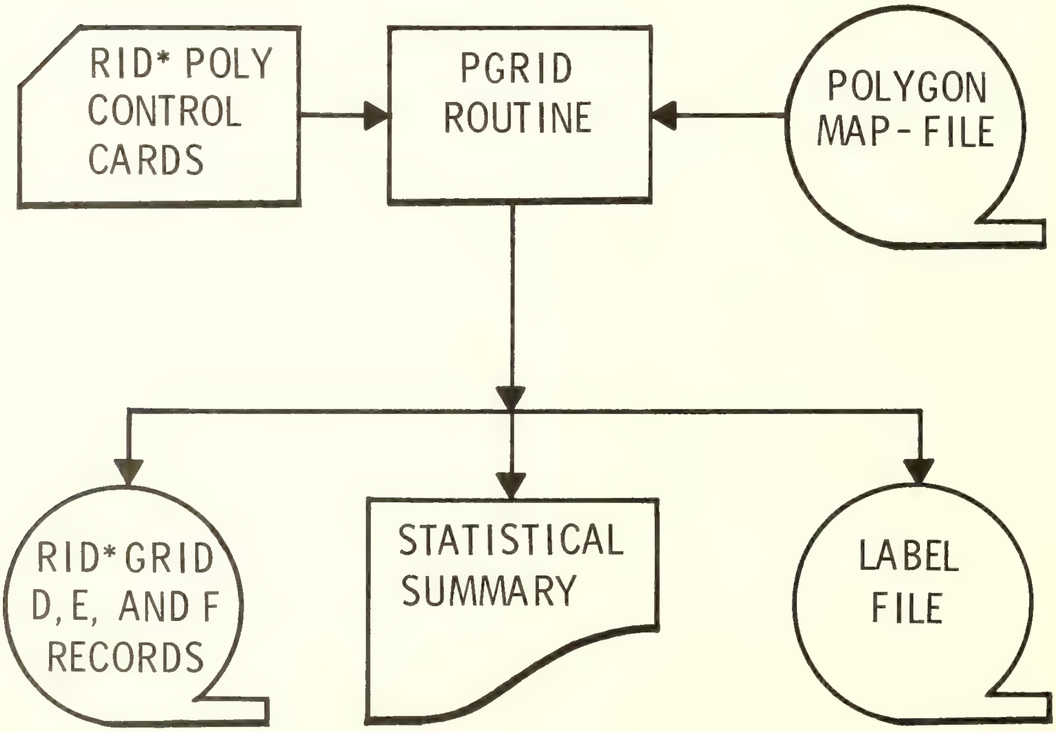
Flowchart 0.4.—Combining polygon map-files (MERGE).



Flowchart 0.5.—Updating a polygon map-file (TONIC).



Flowchart 0.6.—Producing data in the Universal Exchange Format (XCHG).



*Flowchart 0.7.—Converting RID*POLY data to RID*GRID data (PGRID).*

1. DEFINITIONS

BINARY MAP A map consisting of ones ("1") and blanks (" "), ones representing polygon boundaries and blanks representing background, produced on a line printer.

BINARY MAP-FILE A binary map stored on a magnetic tape.

BIPRIN A RID*POLY program used to convert a binary or density file into a binary map-file. This program is used also to correct a binary map and produce an updated binary map-file.

CHART A RID*POLY program which plots a polygon map-file.

CONTROL CARD Eighty-column card images that contain control sections and entities. These cards instruct the RID*POLY programs to perform a specific task.

CONTROL POINTS Reference points used to orient the map sheet and the binary map to absolute geographical location.

CONTROL SECTION The syntax of RID*POLY consists of free-format entities in the form "keyword = list". Each entity has a predefined function. Entities that are logically related are combined into categories called control sections. Each control section consists of an identifier followed by a colon, for example, FILES:, HEADER:, OPTIONS;, etc. The control sections are described in section 2.3.2.

ENVELOPE A set of four points (minimum and maximum x and y) that delineates a rectangle encompassing a polygon (usually the perimeter polygon).

ENTITY The basic form of the RID*POLY syntax is "keyword = list" called an entity.

HANDY A RID*POLY program used to convert digitized data into a binary map-file.

HEADER A collection of keyword information that identifies a map-file.

ISLAND A polygon that is not attached to another polygon or the map perimeter in at least two places.

ITEM During the polygon extraction process (POLLY) a sequential number, beginning with 1, is assigned to each polygon. This number is called an ITEM number and is used to identify the polygon: ITEM 10.

KEYWORD A set of characters that the RID*POLY program recognizes as a signal to invoke a specific action.

LABEL A character string, containing 1 to 36 characters, that identifies the characteristics of a polygon.

LABEL COMPONENT A subset of a label that identifies a specific characteristic of a polygon. A label component is delineated by an "&", for example, STATE LAND&620&RANGE.

LAYER A characteristic or quality of a geographical area that is represented in cartographic form.

MAP A drawing of a characteristic or quality of a geographical area on a flat surface.

MAP-FILE A unit of information, stored on a magnetic tape, that describes (in a format recognizable by RID*POLY) an attribute of a geographical area: quadrangle, township, county, state, etc.

MASK A method of coding labels for selection purposes such that part of a label, part of a label component, or an entire label component can be made transparent.

MERGE A RID*POLY program that combines two polygon map-files.

MOSAIC A RID*POLY program used to overlay two polygon map-files.

OVERLAY PROCESS The procedure in which the intersections of two polygons are assembled into polygons.

PERIMETER A polygon that encompasses all polygons within a map.

PGRID A RID*POLY program that converts a polygon map-file into a RID*GRID file.

OLLY A RID*POLY program that extracts polygons from a binary map-file and produces a polygon map-file.

OLYGON A multi-sided figure that delineates an area containing homogeneous characteristics.

OLYGON MAP-FILE A polygon or group of polygons with identification stored on a magnetic tape.

OLYGON PERIMETER The x and y coordinate pairs that delineate a polygon.

LIVER A polygon of insignificant size (area perimeter ratio less than a specified value) produced during the overlay process by polygon boundaries that almost coincide.

ONIC A RID*POLY program used to change, correct, or update a map-file.

INDOW A rectangular subset of a map.

CHG A RID*POLY program used to convert a polygon map-file into a format (Universal Data Exchange Format) that can be used by other information systems.

2. PROGRAM NOTES

2.1 Files

Data processed by the RID*POLY programs are stored as map-files on magnetic tapes. A map-file is a unit of information pertaining to one map. The tape on which a map-file is read or written has a name, referred to as the volume serial number. Each program requires this name to be entered on the RID*POLY control cards. For example, if the input map-file is on tape CC3930, the following card is necessary:

```
FILES: INPUT=CC3930$
```

The same convention should be followed for specifying an output map-file. Occasionally an output map-file is not required. In this case the OUTPUT file parameter should be recorded as OUTPUT = NONE; on the RID*POLY control cards.

Each map-file has a MODE attribute appearing in the header record automatically generated by the RID*POLY programs. The MODE identifies the type of data a map-FILE CONTAINS (see section 2.3.2.2).

2.2 Special Characters

Certain characters are used as delimiters in the RID*POLY syntax and should not be used in any other context. The special characters and their meanings are as follows:

‘	A quote mark signals the beginning or end of a comment—‘this is a comment.’
:	A colon delineates a control section (HEADER:) or to indicate a sequence of numbers (3:5).
=	The equal sign assigns values to keywords or variables—SCALE = 31680.
⟨⟩	Brackets enclose repeating coordinate pairs—⟨15,21:150⟩.
;	A semicolon terminates a keyword phrase—FOREST = ST.JOE;.
$	A dollar sign signals the end of a control section—HEADER: FOREST = ST. JOE;SCALE = 31680$.
,	A comma separates arguments in a keyword list—INCLUDE ITEMS = 1,2,3:50,51$.
&	The ampersand separates a label into components that can be individually accessed—620&RANGE&STATE. (A label can have a maximum of 10 components.)
#	The number sign masks components of a label—INCLUDE LABELS = 620&#&STATE;.
( )	Parentheses indicate the repetition of a quantity—5(4) represents 4,4,4,4,4.

23 Card Formats

Card input to the RID*POLY programs consists of two types: system cards and RID*POLY control cards.

2 .1 System Cards

System cards are dependent on the computer installation on which the RID*POLY programs are being run. The r s and examples presented in this manual are designed to operate RID*POLY on an Amdahl 470 V6 (VS2/MVS) at Vashington State University, Pullman Wash.

The complete set of system cards (Job Control Language-JCL) required to execute the RID*POLY programs are st d as a member of a partitioned data set (for a listing see appendix A). Whenever a RID*POLY program is requ ted for execution by an EXEC card, for example,

```
// EXEC WRIS,PROG = CHART
```

the full set of system cards is automatically retrieved and the program is executed.

The system cards necessary to execute a RID*POLY program will be discussed in the following section.

1. Job card. Gives job information.

```
//Jobname JOB (accnt number,,line limit),name,MSGLEVEL = (1,1),TIME = time limit
```

Example:

```
//CHART JOB (5099xxx,,20),WALLY,MSGLEVEL = (1,1),TIME = 2
```

2. Procedure library. Data set containing the system cards (JCL) for the RID*POLY programs. See appendix A for a complete list.

```
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
```

3. Program initiation. This card selects a RID*POLY program for execution.

```
// EXEC WRIS,PROG = program name
```

where program name is one of the following:

```
        FREQTB

        BIPRIN

        HANDY

        POLLY

        CHART

        MOSAIC

        TONIC

        MERGE

        XCHG

        PGRID
```

The amount of memory required to execute the RID*POLY programs is given in table 2.1.

4. Input. This card signals the beginning of the RID*POLY control cards.

```
//INPUT DD *
```

Table 2.1—RID-POLY memory requirements

RID*POLY program	Core (*1024 bytes)
FREQTB	400
BIPRIN	400
HANDY	450
POLLY	520
CHART	490
MOSAIC	670
TONIC	550
MERGE	550
XCHG	420
PGRID	440

2.3.2 RID*POLY Control Sections

Information that governs the selection and processing of map information is supplied by RID*POLY control cards. Control cards are classified by section, each designed to perform a specific function.

All RID*POLY control cards are recorded in a free-field format, which means that entities do not have to appear in specified card columns. The basic building blocks of any control section are entities of the form keyword = value, where the keyword on the left is from a standard list of keywords and the value on the right can be a number, several numbers separated by commas, or a string of characters. Extra spaces can be inserted in a control card provided they are not in the middle of a number or word. When coding control cards that extend beyond column 80, continue in column 1 of the next card, as if it were one long, continuous card.

To form a complete control section: (1) enter the name of the control section followed by a colon, (2) enter one entity after another separated by semicolons, and (3) enter a dollar sign to signal an end of control section. For example:

```
HEADER: FOREST = ST.JOE;MAP = 33;LAYER = HABITAT$
```

The control sections listed below pertain to the entire RID*POLY system. Subsequent chapters of this manual indicate the control sections needed for each of the RID*POLY programs.

2.3.2.1 FILES

The FILES section is used to specify tapes that are to be used for input and output operations. Possible keywords are:

INPUT = the volume serial number of the input tape (character).

INPUT ONE = the volume serial number of the first input tape for programs that require two input map-files.

INPUT TWO = the volume serial number of the second input tape for programs that require two input map-files.

OUTPUT = the volume serial number of the output tape (character).

2.3.2.2 HEADER

A **HEADER** record is a collection of keyword information that pertains to a map-file. Three keywords (**FOREST**, **MAP**, and **LAYER**) are used to identify a map-file and must be coded correctly before an existing map-file can be accessed. Other keywords are entered or generated by the various RID*POLY programs. Whenever a map-file is processed, its current header record is printed in full. The header record is stored in the map-file at all times.

Capital letters give the "official" keywords, in the only spelling recognized by RID*POLY (only one blank should be used between words). Character strings may be any length, but they should not be any longer than necessary.

The following list contains all possible keywords that can appear in a **HEADER** record.

FOREST = The name of the forest. (characters)
MAP = Map number. (integer)
LAYER = Layer name. (characters)
LOCATION = Location. (characters)

SCALE = Representative fraction denominator, defined as the number of units on the ground represented by 1 unit on the map. For example, a 4-inch-per-mile map has a representative fraction of 1/15840 and should be coded **SCALE = 15840;**. (integer)

GEOGRAPHIC CONTROL POINTS = Latitude and longitude of each control point, latitude preceding longitude for each point. These points can be entered in degrees, minutes, and seconds (separated by colons) or their decimal equivalents. Do not omit zeroes. In the seconds position, you can record to the nearest hundredth second using a decimal point. An accuracy of at least 0.5 second is essential. The maximum meaningful accuracy is 0.01 second. For example, **GEOGRAPHICAL CONTROL POINTS = 47:45:15.05, 115:45:15.1, 47:45:15, 115:30:00.02;**

MAP CONTROL POINTS = x and y coordinates of the control points, in units of 0.01 inch on the map (**MAP CONTROL POINTS = 100,100,100,1202,1905,1202,1905,100;**). (integers)

GRID CONTROL POINTS = Row and column coordinates from the binary map which correspond to the selected **MAP CONTROL POINTS** (**GRID CONTROL POINTS = 1160,7,5,120,5,1400,1160,1409;**). (integers)

SCAN ROWS = Number of rows on binary map. (integer)
SCAN COLUMNS = Number of columns on binary map. (integer)
MODE = n. Identifies the type of map-file where n is an integer representing:

- 1 = scandig density map-file.

0 = scandig binary map-file.

1 = binary map-file.

2 = polygon map-file with a perimeter polygon (POLLY).

3 = polygon map-file without a perimeter polygon (MOSAIC).

ENVELOPE = Overall envelope of all polygons on the map, namely, the smallest x, smallest y, largest x, and largest y. Same units as map control points. These values are calculated by the system. (integers)
DATE WRITTEN = The date the map-file was written.
TIME WRITTEN = The time the map-file was written.
REEL NUMBER = Tells what reel number the map-file is on.
POSITION ON REEL = Indicates the map-file position on the reel. (integer value)
ZONE = Zone number of map in the State plane coordinate system.
STATE = Name of State for State plane coordinate system.

.3.2.3 HEADER UPDATES

This section allows for modification of information in the header record; existing items can be updated or new tems can be added. The keywords described in the previous section (2.3.2.2) are the same for this section.

xample:

EADER UPDATES: MAP = 30; LAYER = HAUGAN QUAD$

.3.2.4 OPTIONS

This section allows certain program options to be selected. Refer to the appropriate chapter (BIPRIN, POLLY, HART, etc.) for specific information.

3.2.5 CORRECTIONS

This section is used by BIPRIN or POLLY to make corrections in a binary map. Items are:
ADDS = list of x-y coordinate pairs, where "one" bits are to be inserted on a binary map.
DELETES = List of x-y coordinate pairs indicating locations on a binary map where "one" bits are to be moved. Guidelines for coding corrections are listed in chapter 4.

3.2.6 LABELS

This section is used by the POLLY program to attach labels to polygons during the polygon extraction process e chapter 5). The first card of this section must be:

BELS: LIST =

e list of labels must start on the following card. See chapter 5 for more information on recording polygon labels.

.2.7 PLOT OPTIONS

This section is used in the CHART program to select various plot options (see chapter 6).

.2.8 MOSAIC OPTIONS

The section is used to specify options for the overlay procedure; see chapter 7 for further information.

2.3.2.9 POLYGON SELECTIONS

A subset of the polygons in a map-file can be selected for processing by a program. The selection is made by specifying polygons to include or exclude. The specifications involve six variables: item number, type, label, area, perimeter, and envelope. Any combination of the six may be used except item number, which must be used alone. A combination may involve both inclusions and exclusions but not on the same variable. When a combination is used, a polygon must meet all of the criteria given in order to be selected.

Entities are punched on cards in the standard format "keyword = list".

The keywords are:

1. **INCLUDE ITEMS** = list of item numbers;
   or
   EXCLUDE ITEMS = list of item numbers;

This option is used to select a subset of polygons from a polygon map-file by explicitly identifying polygons to be included or excluded by their item numbers. For example,

POLYGON SELECTIONS: INCLUDE ITEMS = 1,10,50,75:80$

will select a subset of polygons containing items 1,10,50,75,76,77,78,79,80. The maximum number of items that can be included or excluded is 2047.

This option cannot be used with any other options under this section.

2. **INCLUDE TYPES** = list of type numbers;
   or
   EXCLUDE TYPES = list of type numbers;

This option is used to select points (TYPE = 1), lines (TYPE = 2), or polygons (TYPE = 3). As of the date this manual was written, RID*POLY was designed to process only polygon data.

3. **INCLUDE LABELS** = label list;
   or
   EXCLUDE LABELS = label list;

This option is used to select a subset of polygons by specifying labels or label components. If polygons are to be selected by labels, then the label list should contain the desired labels. If polygons are to be selected by label components then the "#" (number sign) should be used to mask unwanted components of a label. For example,

POLYGON SELECTIONS: INCLUDE LABELS = STATE#&620&#$

will select a subset of polygons which has labels such that: (1) component one begins with the characters **STATE**, (2) component two contains only the characters **620**, and (3) component three contains any characters.

4. **INCLUDE AREAS GREATER THAN** = x;
   and/or
   EXCLUDE AREAS GREATER THAN = x;

This option is used to select a subset of polygons based on their size. The variable x is a floating point number representing acres. For example, POLYGON SELECTIONS: EXCLUDE AREAS GREATER THAN = 1000.0$

will select a subset of polygons which has areas of 1,000 acres or less.

5. INCLUDE PERIMETERS GREATER THAN = x;
   and/or
   EXCLUDE PERIMETERS GREATER THAN = x;

This option is used to select a subset of polygons based on the length of their perimeter (boundaries). The variable x is a floating point number representing feet. For example,

POLYGON SELECTIONS: INCLUDE PERIMETERS GREATER THAN = 2050.0$

will select a subset of polygons that has perimeter lengths greater than 2,050 feet.

6. INCLUDE RECTANGLE = min x, max x, min y, max y;

This option is used to select a subset of polygons that are contained completely within a specified rectangle (window). he min and max values are integer numbers (in units of 0.01 inch) representing map coordinates. For example,

OLYGON SELECTIONS: INCLUDE RECTANGLE = 100,800,500,1000$

ll select a subset of polygons that has only x coordinates between 100 and 800 and y coordinates between 500 and 1000.

3.2.10 END$

This section is used to signal the end of control sections for the map currently being processed. If multiple maps are to be processed in a single run, the **END$** section should be entered as the last control section for each map.

4 Integer Lists

Many programs will require a list of integers, whole numbers without decimal points, as input from cards at some point (some header record keywords are in this form). Rather than require a fixed field size and card location for each number, we use a free format. The integers are punched in as many columns as are needed. Successive integers are separated by commas. The list is terminated by either a semicolon or a dollar sign, depending on context. Information can be continued on the next card as if it were one long card. However, to facilitate future changes, information should not be spanned across cards. Blanks (skipped columns) can be inserted anywhere except between the digits of a number.

Three abbreviations are possible: (a) A sequence of increasing or decreasing numbers such as ‘‘6, 7, 8, 9’’ can be shortened to ‘‘6:9’’. (b) A repetition of the same numbers, such as ‘‘4,4,4,4,4’’ can be abbreviated ‘‘5(4)’’. A combination is possible, such as ‘‘2(5,7:9)’’, which is the same as ‘‘5,7,8,9,5,7,8,9’’. In other words, whatever is inside the parentheses is repeated as many times as the number in front indicates. (c) For ease in recording sequences of coordinate pairs, we allow the special forms ⟨x,a:b⟩ and ⟨a:b,y⟩. The lower case letters stand for integers. For example, ‘‘1,617:653⟩’’ is the same as ‘‘31,617,31,618,...,31,653’’.

2. Comments

Comments can be included anywhere in the RID*POLY cards by enclosing the comment material in quote marks. A comment is information that you do not want the RID*POLY programs to read. Whenever a program encounters a quote mark in the input stream, it scans forward until the matching quote mark is found and resumes processing at that point.

2.6 Printout

Certain information occurs on almost every printout and may need some explanation. All RID*POLY control cards are printed with the label, **INPUT CARD**. This helps you check your work in case of error. Every page printed by a RID*POLY program is headed by the program name, the date, time of day, and a page number. The message **END OF RUN** is printed at the end. Most of the input information is printed back as cards, showing you how the data have been supplied to the computer. This helps you spot errors. Whenever there is an output map-file, the message **OUTPUT FILE WRITTEN** will be printed after the writing is complete. You need this message to be sure the map-file can be read as input in a future run.

2.7 Limitations

The maximum number of polygons that can be selected in the POLYGON SELECTIONS section is 3,000.

The maximum number of labels that can be selected in the POLYGON SELECTIONS section is 250.

The maximum number of points in a polygon perimeter is 1,991.

The maximum number of polygons in a map-file is 5,000.

The maximum number of polygons in an overlay map-file is 5,000 minus the number of polygons selected from each input polygon map-file.

The maximum number of characters in a label is 36.

The maximum number of label components is 10.

3. PREPARING MAPS

Proper map preparation is the most important step in the digitizing process. Avoiding errors here has a greater impact on cost than at any other stage. Two sources of errors can be eliminated: poor ink quality and logical map errors.

3.1 Automatic Scanning

Maps can be drafted at any scale such that after an 8x to 11x reduction a photographic negative of the map can be obtained to fit the scanning bed or drum of a microdensitometer (maximum of 9 inches by 9 inches for SCANDIG). Line width on the map sheet should not be wider than the narrowest gap betweeen lines. (A line width of 0.5 mm, size of a #2 Rapidograph pen, on a 610 mm by 610 mm map has proved satisfactory for most applications.) The aperture setting (size of spot measured) on the scanner should be half the width of the lines on the negative.

Ink lines should be of uniform width and uniform density. Moving the pen too rapidly along a straight edge when nking straight boundaries produces a thin, weak line. A good quality inking job can eliminate corrections in later tages.

At this stage, common errors are failure to label a polygon or double labeling of a polygon. A polygon may be ouble labeled because it looks like two polygons or because the line separating two polygons is not inked.

Maps to be digitized with a scanner must be specially prepared. With a #2 Rapidograph pen, draw in black ink he polygons to be digitized. Polygons must not overlap and should fill the area to be digitized. Labels or other map eatures, if entered on the map sheet, should be written with a photo-transparent blue pigment pencil (EAGLE erithin nonphoto blue 740 1/2) and thus will not appear on the photographic negative. Only one layer of information ttribute) should be entered per map sheet, for example, timber type, management constraints, or administrative oundaries. To completely fill an area with polygons, assign a special label to all areas that are not of interest. This ep is critical for finding all errors during the editing process. The map must also be free of islands (fig. 3.1). Remove ands by connecting them to the ''mainland'' in two separate places (fig. 3.2). Eliminating islands creates new olygons that must be labeled with the same label as the polygon they were split from. The new polygons should be rge enough for a label to fit inside.

Complexity does not affect the computer time required to process an automatically-scanned map. The number of ensity readings that must be taken on a simple map are the same as on a ''busy'' one. On a simple map, however, early all readings are zeros. Therefore, a simple map is relatively expensive to process by the scanner method, considering the small amount of information collected.

3.2 Manual Digitizing

Another method of inputting data to the RID*POLY system is to manually digitize the polygon boundaries. This method utilizes a hand-guided digitizer and a program (HANDY) that processes its output into the same form produced by FREQTB or BIPRIN. Because of its limitations, this method is an alternative rather than primary method. Users should choose the scale and area of their maps in such a way that most of the work can be efficiently processed by the scanning method, leaving only a small part to be hand digitized.

No special preparation of maps is needed for the hand digitizing process, but logical errors must be avoided. Tape the map to the digitizer surface. Move the cursor over all lines that are to be recorded. A boundary may be recorded in as many pieces (records) as necessary as long as no gap is left between pieces. A small overlap of x-y coordinate pairs is desirable at the end of polygon boundaries and T-shaped intersections. Point mode, recording only the end points, should be used for straight lines. (Point and line mode are interchangeable.)

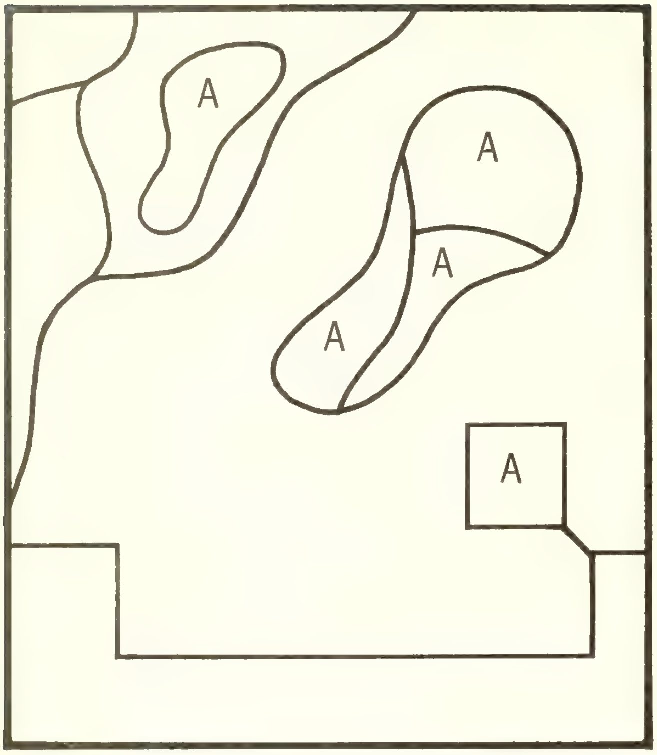


Figure 3.1.—Polygon Islands.

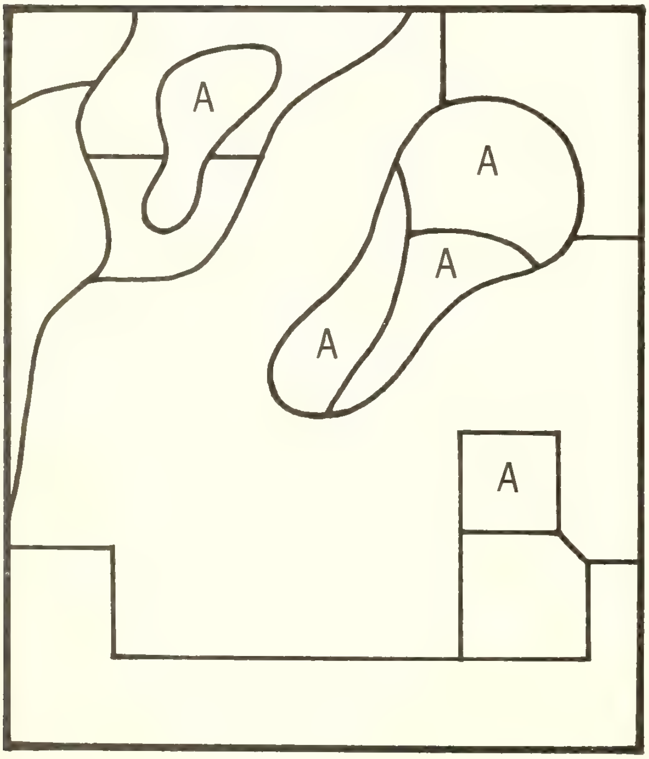


Figure 3.2.—Islands connected.

4. PROCESSING INPUT DATA

4.1 Processing Density Data (FREQTB)

FREQTB reads density tapes produced by automatic scanners, which record image density on a scale from 0 to 63 (using the six high-order bits of each density reading). The program tabulates the frequency distribution of the densities and produces a binary tape. FREQTB computes a threshold by subtracting the **DENSITY ADJUSTMENT FACTOR** from the mode of the density frequency table. Each six-bit value is converted to a one, if below, or to a blank, if above, the established density threshold. The resulting matrix of binary values (binary map) duplicates the scanned negative, with ones representing lines (low density) and blanks representing the background (high density). The one/blank values are written compactly on tape for use by BIPRIN or POLLY. Printed output is a binary map in which polygon boundaries are delineated by ones.

There are three versions of FREQTB: FREQ1 is designed to process density readings from a PDS-1010A scanner (Perkin-Elmer Corportion, South Pasadena, Calif.); FREQ2 is designed to process density readings from a PDS-1010 (old Berkeley scanner); and FREQ3 is designed to process density readings from a SCANDIG scanner.

The FREQTB routines are not used very often because it is more efficient to produce a binary file and process it hrough BIPRIN. FREQTB should be used only for scanners that cannot produce a binary file. The IBM FREQTB outines simply convert density map-files to BINARY map-files, thus, they do not follow the RID*POLY program onventions.

nput cards:

1. System control cards (required). See appendix A.

```
(JOB CARD)
*TO USFS
PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
EXEC PROG = FREQTB,INTAPE = nnnnnn,INLAB = n,OUTAPE = mmmmmm,OUTLAB = m
FREQTB.INPUT DD *
```

here:

nnnnnn represents the volume serial number of the tape that is to be used as input.

n represents the file number to read from above input tape.

mmmmmmm represents the output tape on which the binary map-file is to be written.

m represents the file number to write on the output tape.

(For further information on FREQTB procedures see appendix A and for system cards see section 2.3.1.)

2. RID*POLY control cards
   a. xxyy (required)

      xx - 2 digit number which specifies the number of maps to process in the current run.

      yy - **DENSITY ADJUSTMENT FACTOR**. Integer number between 0-63 used to specify the cutoff level between ones and blanks (background) on a binary map. If left blank, cutoff will be calculated.

   b. Header record. (required)
      One card containing **FOREST,LAYER,MAP,LOCATION**, and **MODE = 1**

Sample Input Deck:

```
//FREQTB JOB (acc.no.,,30),NAME,MSGLEVEL = (1,1),TIME = 2
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// EXEC PROG = FREQTB,INTAPE = CC3930,INLAB = 3,OUTAPE = CC4530,OUTLAB = 1
//FREQTB.INPUT DD *
01
FOREST = ST.JOE; MAP = 33; LAYER = HABITAT; LOCATION = HAUGAN; MODE = 1$
//
```

4.2 Processing Binary Data (BIPRIN)

BIPRIN reads a binary tape (from the SCANDIG scanner, the FREQTB program, or a previous BIPRIN run), applies any corrections or updates (see section 4.4, Editing a Binary Map), prints selected parts of the resulting binary map, and writes a corrected binary map-file on tape (if directed). BIPRIN is very useful for editing maps which require many corrections, because (unlike POLLY) the edited binary map-file may be kept.

Input Cards:

1. System cards. (required)

```
//WRISRUN JOB (acc#,,30),name,MSGLEVEL = (1,1),TIME = 2
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// EXEC WRIS,PROG = BIPRIN
//INPUT DD *
```

2. RID*POLY control cards. (see section 2.3 for exact formats)
    a. FILES: (required)

The FILES section identifies the tape reels that are to be used for input and output. An input tape is required and must have the volume serial number specified. The output tape is not necessary unless changes to the binary map or the header record produce an output map-file that is to be saved. If an output file is specified, then it must specify the volume serial number of the tape used for output.

b. HEADER: (required)

The HEADER section is used to select a binary map-file for processing (see section 2.3.2.2 for further information). MAP, FOREST, and LAYER are required to locate the correct input map-file. They must be specified exactly as they were entered in the HEADER record on the scanner output file.

c. HEADER UPDATES (optional)

This section is used to add information to the header record or to correct it.

d. OPTIONS: (optional)

This section is used to select various features of the BIPRIN routine. Available options are:

SKIPS = n; causes the input tape to be positioned forward over n map-files. This option is particularly useful when the same identifier has been used accidentally in two or more map-files on the input tape.

PRINT = CORNERS/ALL/NONE; indicates the print output desired for a binary map.

An alternate method of specifying map areas to be printed is:

```
ROWS = n1, n2, n3, n4;
COLUMNS = m1, m2, m3, m4;
```

This example would result in two map areas being printed. The first area is bounded by rows n1 and n2 and columns m1 and m2. The second area is bounded by rows n3 and n4 and columns m3 and m4. Up to 4 areas can be specified for each map. If only ROWS are specified, a strip the width of the map will be printed, as the COLUMNS values default to the first and last column values of the map. Similarly, if only COLUMNS are specified, the ROWS values default to the first and last map row values.

PRINT = and ROWS = ,COLUMNS = are mutually exclusive.

FLIP = SIDE/UP; is used to reverse a binary map from side to side *or* top to bottom. No reversal is done if FLIP is not in the OPTIONS section.

THIN/NOT THIN; indicates whether the lines on the binary map are to be thinned.

LEAVE ENDS/TAKE ENDS indicates whether to remove ends of lines during the thinning process. TAKE ENDS should be used cautiously, as a gap in a needed line may be widened. An example of a use for TAKE ENDS is to eliminate unintentional stray marks that show up on the binary map. TAKE ENDS is useless unless the THIN OPTION is in effect.

ITERATIONS = n; places a limit on the number of passes the line-thinning routine makes over the binary map. Very sloppy ink work on the original map may require five or more iterations. This option is useless unless the THIN option is in effect.

SWAPXY; used to switch the x-y coordinate values in the corrections section. The x-y values are switched rom column-row to row-column form. For example, 90,1500 would be switched to 1500,90.

Options can be in any order within the OPTIONS section.

The following list indicates default values for BIPRIN:

Option	**BIPRIN default**
SKIPS	0
PRINT	ALL
FLIP	Not flipped
THIN/NOT THIN	NOT THIN
LEAVE ENDS/TAKE ENDS	LEAVE ENDS
ITERATIONS	5
SWAPXY	row-column

e. CORRECTIONS: (optional)

This section is used to make corrections on a binary map. For further information on correcting a binary map see ction 4.4.

mple Input Deck:

```
/OB (,,35),BIPRIN,MSGLEVEL = (1,1),TIME = 2
/.ROCLIB DD DSN = GINDX.Y1978.USFS,PROCLIB,DISP = SHR
/.EXEC WRIS,PROG = BIPRIN
/NPUT DD *
F.ES: INPUT = WRIS01; OUTPUT = NONE$
F:ADER: FOREST = ST.JOE:LAYER = TENSED HAB.;MAP = 2017$
F ADER UPDATES: FOREST = ST.JOE;LAYER = HABITAT;MAP = 59;
L CATION = TENSED$
C TIONS: NUMBER OF MAPS = 1; PRINT CORNERS; THIN; ITERATIONS = 3$
```

See appendix F.1 for the actual execution of this job stream.

4 Processing Digitizer Data (HANDY)

The HANDY program receives as input, data written by a digitizer. Output is a tape that appears the same as th output of FREQTB; a map scanned on a grid having a spacing of 0.02 inch. HANDY constructs a grid of that sp ing, presets all of its points to the value 0, and then changes to 1 all points that a digitized line passes over. Thus, ov lapped segments are merely redundant. Any spur-like overruns are pared off during later processing.

Input cards:

1. System control cards (required). See appendix A.

```
//(JOB CARD)
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// EXEC WRIS,PROG = HANDY
//INPUT DD *
```

2. RID*POLY control cards. (See section 2.3 for more information)
    a. FILES: (required)
    This section is used to identify the input and output tapes.
    b. HEADER: (required)
    This section is used to build a HEADER record for the binary output map-file.
    c. OPTIONS: (optional)
    SKIP = n$ causes the input tape to be positioned forward over n files.

Sample Input Deck:

```
//JOB (,,35),HANDY,MSGLEVEL = (1,1),TIME = 2
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// EXEC WRIS,PROG = HANDY
//INPUT DD *
FILES: INPUT = WRIS01; OUTPUT = NONE$
HEADER: FOREST = ST.JOE;LAYER = LAND USE;MAP = 100;
LOCATION = BUZZARD ROOST$
OPTIONS: SKIPS = 1$
```

See appendix F.3 for the actual execution of this job stream.

4.4 Editing a Binary Map

Most binary maps will not require extensive editing if spacing, aperture, and ''threshold adjustment'' of the microdensitometer have been properly selected and if good quality maps were scanned. For these maps the PRINT = CORNERS option in BIPRIN is all that is needed to get the GRID CONTROL POINTS (see section 5.1). A square or rectangular map of good quality will not require a BIPRIN run if the corners are the four control points, because POLLY automatically finds the corner points and uses them as GRID CONTROL POINTS.

4.4.1 Editing Guidelines

The general procedure is to mark all errors on the computer printout (binary map). Next, record all corrections on data forms for keypunching. The printout is a series of vertical strips, commencing with the left-most edge of the map.

Visually scan each strip, comparing it with the map or a photo of the map for errors. Careful editing of the printout at this stage will save considerable time and cost later. Correct each error by circling with a red pencil each ''1'' to be deleted and circling with a blue or green pencil each space where a ''1'' is to be added. Put a check in the right margin if one or more corrections occur in a row. These checks will help to avoid omissions at the data recording stage. Blocks of 10 lines are not printed if they are blank.

Follow these rules for adding or deleting 1's:

1. Fill in gaps in lines with as few points as possible (fig. 4.1).
2. Open the gaps between close lying lines (fig. 4.2).

Hints for editing:

1. Construct "rulers" consisting of the column heads for each strip. Insert rulers in the printout at the beginning of each strip. This helps to minimize the error of forgetting to change rulers at the beginning of each strip. Row numbers are printed along the right side of the strip. The strip number is printed in a column to the right of the row number.

2. Inspect each string of 1's for gaps in lines, small polygons, and areas with a high density of 1's. The gaps are potential areas for corrections. Two 1's are considered connected if they are in adjacent spaces either vertically, horizontally, or diagonally. Look particularly for polygons with only a few interior cells. Such polygons are hard to spot when they are formed by diagonal connections. Two kinds of features that can cause extra small polygons are cute corners of a boundary with a small interior angle and two parallel boundaries that are close together on the map ut not separate on the printout.

3. Because each addition and deletion must be recorded and keypunched, corrections should be kept to a ninimum.

4. Two polygons connected by a narrow neck on the map may have two different labels. Therefore, take care vhen correcting this kind of gap.

5. The first two columns on each strip are repeats of the last two columns of the previous strip. These columns lmost eliminate the need to refer to previous strips while making corrections. Any correction to a repeated column eed only be made once.

6. Ignore stray 1's that result from photographing portions of labels or specks of dirt. The POLLY program will nore them. The polygon also ignores any piece of a line that is not part of a loop. This is proper if the line was producd by a smudge but will result in an error if it is due to a gap in an inked line.

7. The printout should be edited twice, each time by a different person. Usually, additional omissions will be und and the list will lengthen.

```
1111111111111111111111        1111111111111111111111
1                    1        1  1                 1
1                    1        1   1                1
1                  111        1    1               1
1                111 1        1     11             1
1             111    1        1       11           1
1             11     1        1       11           1
1             11     1        1       11           1
1   11       1       1        1           11       1
1 11         1       1        1            11      1
111          1       1        1             11     1
1            1       1        1              11    1
1            11      1        1               1    1
1             11     1        1               1    1
1               1    1        1              1     1
1               11   1        1             11     1
1111111111111111111111        1111111111111111111111
1                    1        1            11      1
1                    1        1                    1
1       111          1        1            11      1
1       111          1        1            11      1
1    111    11       1        1            1       1
1  111      11       1        1            11      1
1111         1       1        1            1       1
1            1       1        1            1       1
1            1       1        1            1       1
1            1  11   1        1            11      1
1           1111  11 1        1            1       1
1           1        1        1            1       1
1          11        1        1                    1
1         11         1        1            11      1
1         1          1        1            1       1
1         1          1        1            1       1
1        11          1        1            1       1
1111111111111111111111        1111111111111111111111
1                    1        1                1   1
1                    1        1               1    1
1                    1        1              11    1
1111  11     11      1        1             11     1
1 11 11       11     1        1            11      1
1  111         11    1        1           11       1
1   11          11   1        1           11       1
1   11           1   1        1111111111  1        1
1    1           11  1        1111        1        1
1    1            11 1        1          11        1
1    1             111        1          1         1
1    11             11        1          1         1
1     1              1        1         1          1
1    11              1        1         11         1
1      1             1        1          1         1
1     11             1        1          1         1
1111111111111111111111        1111111111111111111111
```

Figure 4.1.—Example of lines needing ADDS.

```
1111111111111111111111       1111111111111111111111
1              11    1       1        11          1
1              1     1       1        11  111     1
1             11     1       1        1  111111   1
1            11   1111       1       11 11   111  1
1           111  111 1       1       11 1     11  1
1         111 111    1       1       11 1      11 1
1        1111111     1       1       11 11    11  1
1      1111111       1       1        1 111     111
1     111 111        1       1        11 11       1
1    11  11          1       1       111111       1
1   11 111           1       1      11  11        1
11111 111            1       1      11
1111  11             1       1     11             1
1    11              1       1     1              1
1   11               1       1111 11              1
1  11                1       1 11111              1
1 11                 1       1    1111            1
1 1                  1       1       11           1
1111111111111111111111       1111111111111111111111
1       11        1111       1              11    1
1        1     11111 1       1             111    1
1       11   1111    1       1           1111     1
1       11 1111      1       1        11111       1
1       11111        1       1       111          1
1       1111         1       1      1111          1
1       111          1       1      11 11         1
1       1111         1       1      11  1   11111 1
1       11111        1       1       1111111111 111
1       11 1111      1       1        11111      11
1       11   111     1       1                    1
1       11     11    1       1                    1
1       11     11    1       1                    1
1       11     11    1       1                    1
1111111111111111111111       1111111111111111111111
1      1             1       1                    1
1     11     1       1       1                    1
1     11    11111111 1       1111111              1
1    11    11   111111       1111111111111111111111
1    11   11         1       1  111    111      111
1   11    11         1       1111     1111111   1 1
1   11    11         1       1       11     11111 1
1  11    11 111111   1       1       1         1  1
1  11   111111 1111  1       1       1            1
1  11  11111      11 1       1       1            1
1  111111 11        11       1       1            1
1   111   1          1       1       11           1
1        11          1       1        1           1
1        11          1       1        11          1
1       11           1       1         1          1
1      11            1       1         1          1
1111111111111111111111       1111111111111111111111
```

Figure 4.2.—Example of lines needing DELETES.

4.4.2 Recording Error Corrections

Next record the "add" and "delete" corrections marked on the FREQTB, BIPRIN or HANDY printout. Start the recording with a card that identifies the adds and deletes: ADDS = or DELETES =. It is helpful to start recording deletes at the top of a separate sheet. Each strip has a ruler for recording column numbers. Look for checkmarks in the right margin opposite rows needing correction. Record adds and deletes by row and column on data forms; examples, 5,62,10,453. For convenience in subsequent editing, start each line with a row entry and end with a column entry followed by a comma. Leave unused columns blank. In this way an item will not be split between lines, and no error will occur if the order of the cards is changed. Long consecutive lists of items in one row or one column may be added or deleted by the following shortcut method:

⟨R,C1:C2⟩, or ⟨R1:R2,C⟩

For more information on the shortcut form of recording integer numbers, see section 2.4.

5. PRODUCING A POLYGON MAP-FILE

Once a map has been digitized and condensed to binary form, it is necessary to generate a file of polygons from it nd to label them. The POLLY program is used to perform this task. This section will describe the steps necessary to et up a POLLY run and edit the output.

.1 Control Points

Control points are reference points that are used to align the binary map, source map, and absolute geographic ocation. Control points must be recorded in three coordinate systems:

GRID CONTROL POINTS are the row and column positions of the control points in the grid coordinate system f the binary map, for example 1100,20.

MAP CONTROL POINTS are the x-y coordinates in hundredths of inches used to locate the labels within their spective polygons, for example, 100,100.

GEOGRAPHIC CONTROL POINTS are the latitude and longitude of the control points, for example, 7:30:15.5,115:15:30.20.

Quadrangle corners are usually selected as control points, although any other sharply defined locations will do. hese are recorded in a clockwise manner, starting in the lower left corner. Four corners are the most desirable, but tree (or even two) may be sufficient. The corner must be a recognizable point on or within the map boundary, not sne arbitrary point on the map sheet. All maps representing the same geographic area should use the same control pints to represent ground locations.

52 Recording Polygon Labels

A label is a string of 1 to 36 characters that identifies the attributes of a polygon. In order to extract polygons fim the binary map, all polygons must be assigned a label and an x-y coordinate to position the label within the pygon.

5 .1 Setup

To record the x-y position of the labels, an axis must be established. The length of each axis must exceed the la est map dimension expected. The vertical or "north-south" direction is designed as the y axis. The map must be pc tioned within the right angle (first quadrant) formed by the x-y axis so that all points on the map are positive, nc zero integers. The x and y distances are recorded from the origin in hundredths of an inch.

5. 2 Label Recording

Start recording labels and their x-y positions on a new line of the data form. Select a coordinate position that is ce rally located in the polygon. Use a photo transparent pencil (sky blue, Eagle 740-1/2 currently available in GSA ca og) to check off each label as it is recorded. An entity consists of a label followed by its x and y position. Entities are eparated by a comma. The last entity is followed by a dollar sign. Within the entity, the three parts are separated by ne or more blanks. The x and the y coordinates are in units of 0.01 inch. Thus, 24 inches from the origin is written s 2400. For example, FOREST 900 1100, RANGE 300 420, FOREST 590 1000;

These data are written as one long "stream;" the end of a line on a data form has no significance. If an entity is not omplete when the last column is reached, it can be continued on the next line. However, it is recommended that an tity be entered on one line and not spanned across lines. This practice will facilitate future changes.

5.3 Extracting Polygons from a Binary Map-File (POLLY)

The POLLY program extracts polygons from the binary map-file by using the label locations as starting points (see section 5.2.2). Corrections to a binary map-file may also be made in POLLY by using **ADDS** or **DELETES**. All the polygons extracted are written on the output tape. POLLY will run a batch of jobs when there is a series of control cards.

Input Cards:

1. System cards. (required)

```
//(JOB CARD)
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// EXEC WRIS,PROG = POLLY
//INPUT DD *
```

2. RID*POLY control cards.

a. **FILES**: (required) contains input and output tape volume serial numbers.

b. **HEADER**: (required) contains forest, map, layer, geographic control points, map control points, grid control points, location, scale, state, and zone.

c. **HEADER UPDATES**: (optional) contains any changes in the input header record which should be on the output tape.

d. **OPTIONS**: (optional)

SKIPS = n; causes the input file to be positioned forward over n map-files.

SWAPXY; is used to switch the x-y coordinate values in the CORRECTIONS section. The x-y values are switched from column-row to row-column form. For example, **90,1500** would be switched to **1500,90**. The default is row-column form.

CHECK HOLES; This option causes the POLLY program to check the binary map for holes (small areas caused by line intersections) and unlabeled polygons. However, the hole-checking routine will not be executed unless all input labels have been successfully extracted and the area of the enclosing polygon (perimeter polygon) exceeds the area of the enclosed polygon by 1 part in 4000. Default is not to check holes.

PRINT ACREAGES; This option will produce a table of acreage figures for the polygons extracted in the current POLLY run.

e. CORRECTIONS: (optional) contains **ADDS** and **DELETES** if any.

f. **LABELS**: (optional) Contains the labels with their x-y locations in map coordinates. If no labels are provided, POLLY uses the upper left-hand corner of each polygon as a label location and assigns the label **NEEDS LABEL** to each polygon. If this section is included, the first card must be:

```
LABELS: LIST =
```

The labels must start on the next card.

g. **END$** (required for multiple runs): This section is used to signal the end of RID*POLY control sections for the map currently being processed. This section is required if more than one map is to be processed in a single run.

ample Input Deck:

```
JOB (,,100),'POLLY TEST',MSGLEVEL = (1,1),TIME = 5
PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB.DISP = SHR
EXEC WRIS,PROG = POLLY
INPUT DD *
ILES: INPUT = WRIS01; OUTPUT = NONE$
EADER: FOREST = ST.JOE; MAP = 59; LAYER = HABITAT$
PTIONS: SKIPS = 2$
EADER UPDATES: FOREST = ST.JOE; MAP = 59; LAYER = HABITAT;
OCATION = TENSED;
ENSED HABITAT ST.JOE'
AP = 059; FOREST = ST.JOE; LAYER = HABITAT; LOCATION = TENSED;
AP CONTROL POINTS =  101,117,102,1857,2460,1831,2463,101;
EOGRAPHIC CONTROL POINTS = 47:00:00,117:00:00,47:07:30,117:00:00,47:07:30,116:45:00,47:00:00,116:45:00;
RID CONTROL POINTS = 39,33,25,876,1164,892,1180,54;
TATE = IDAHO; ZONE = 3; SCALE = 31680; ENVELOPE = 98,98,1850,2465$
ORRECTIONS:
DS =
114,116:118〉,〈32,442:444〉,〈1172,458:466〉,〈1174,404:407〉,
〈9,81:83〉,〈680:691,44〉,679,45,〈680:684,46〉,〈1178,157:158〉,
179,152,911,345,〈35,286:291〉,912,344,302,604,301,605,300,606,
〈98:299,607〉,〈434:437,881〉,〈1013:1015,889〉,1022,890,
〈85:1086,890〉,〈1092:1093,891〉;
LETES =
1 7,121,〈1108,122:123〉,
〈 8,521:522〉,
1 3,117,〈1115,116:118〉,
〈 0:684,45〉,691,46,890,81,890,83,911,346,912,345,〈509:510,453〉,
9 ,403,547,382$
L BELS: LIST =
5 2435 1760,530 2020 710,
9 892 486,999 339 1138,999 1487 1417,
57 536 870,530 750 1140,520 804 1146,530 866 1146,
53 1125 1066,570 1154 999,520 1209 1014,530 1138 936,
57 1145 865,530 1121 807,570 1202 822,530 371 1567,
57 1504 170,530 1381 410,570 1407 441,520 1413 404,
53 1409 368,530 1449 376,570 1453 422,530 1533 525,
53 1690 590,570 1740 641,530 1755 689,570 1824 707,
53 1859 739,570 1912 761,530 1915 806,
53 1899 892,520 2035 738,570 2001 878,520 2210 798,
53 231 764,530 2146 858,570 2171 846,530 2186 876,
53 230 859,570 2255 848,530 2205 974,530 1697 278,
57 713 314,530 1761 331,570 1808 342,570 1818 208,
52 020 428,570 1934 338,530 1979 158,570 1992 280,
57 035 238,530 1895 496,570 1993 499,530 2164 302,
570 425 306,530 2318 380,530 2370 327,520 2367 238,
530 455 232,570 2330 224,999 2366 160,530 2183 206,
570 227 149,570 2431 647,570 2333 840,530 2381 861,
570 338 1070,530 2104 1224,999 2324 1228,530 2436 1392,
530 441 1755 $
```

5.4 Editing POLLY Printout

A printout of a normally terminated POLLY run will consist of the following sections:

1. File names or reel numbers.
2. Header record input from cards.
3. Header record resulting from tape header record merged with card input record.
4. List of corrections for binary map:
    a. Additions input cards.
    b. Sorted list of additions.
    c. Deletions input cards.
    d. Sorted list of deletions.
5. List of labels:
    a. Label input cards.
    b. Sorted list of labels.
6. Output header record.
7. Local label list.
8. Detailed list of extracted polygons.
9. Summary record of number and area of polygons.
10. Confirmation of writing of output file.

For the purpose of editing, this output can be considered in two groups: Items 1-5 deal with input; items 6-10 deal with output.

The printout is organized for the use in editing rather than as a record of data. Errors during input are usually recording, format, or keypunch errors. There are two groups of errors: those that stop the program and those that do not. It is best to start looking at the back of the printout to see if any input errors hve stopped the program. A list of fatal error messages follows:

CONTROL CARD ERROR

Required control sections are not present, are misspelled, or there is a punctuation error. (See section 2.3.)

INPUT/OUTPUT FILE SPECIFICATION ERROR

An input file is required and has not been specified. (See section 2.3 for proper deck setup.)

INPUT FILE IS WRONG MODE

A file with the correct Forest, Map and Layer, was read but it is the wrong mode for the selected program. See section 2.3.2.2 for more information on MODE.

CANNOT RECOGNIZE THE LABEL nnn

The left-hand side of a header record entity (nnn) is misspelled. (See Section 2.3)

INPUT CARD ERROR

The header record card has a format error. (See Section 2.3.)

TOO MUCH DATA ON INPUT CARDS

The total amount of data in the header record is more than the program can handle. See the programer responsible for RID*POLY maintenance.

READ ERROR WHILE READING CORRECTIONS DECK

This error results from format errors such as missing or extra commas, extra brackets, or lack of a record terminator. See the sections on Editing the Binary Map (section 4.4) and on Card Formats (section 2.3).

CORRECTION OUT OF RANGE ROW i COLUMN j

A row or column exceeds the maximum number of rows or columns in the map. The maximum are found in the eader record labelled SCAN ROWS and SCAN COLUMNS

CARD INPUT ERROR

his message indicates a format error while reading labels. (See section 5.2 for label format.)

ND OF FILE WHILE READING LABEL DECK

he usual cause is a missing record terminator.

I S TOO MANY POLYGONS FOR THE ARRAY SIZE

The label array is not large enough. See the programer responsible for RID*POLY maintenance.

If the POLLY printout is not terminated by one of the preceding error messages, the following message may appear in the listing of label input cards. (Processing continues after this error.)

NO COORDINATES FOUND FOR THIS LABEL nn

A recording or keypunching error has resulted in no coordinates being associated with the label nn. This label is ignored and processing continues.

The remaining error messages result from logical errors in the data. They are found during the process of extracting polygons. The messages will be interspersed with the detailed list of polygons. To be able to correct logical errors in the data, some understanding of the polygon extracting algorithms is needed.

Figures 5.1 and 5.2 show the results of thinning the examples illustrated in figures 4.1 and 4.2. Figures 5.3 through 5.7 duplicate figures 4.1, 4.2, 5.1 and 5.2 with the ADD and DELETE corrections applied.

```
 11111111111111111111          11 111111111111111111
1                    1        1  1                 1
1                    1        1   1                1
1                   1         1    1               1
1                111 1        1     11             1
1               1    1        1       1            1
1              1     1        1        1           1
1             1      1        1                    1
1            1       1        1                    1
1            1       1        1                    1
 1           1       1        1                    1
1            1       1        1                    1
1             1      1        1                    1
1              1     1        1                    1
1               1    1        1                    1
1                1   1        1                    1
 1111111111111111 111          111111111111  1111111
1                    1        1            11      1
1                    1        1                    1
1                    1        1                    1
1                    1        1                    1
1                    1        1                    1
1                    1        1                    1
 1                   1        1                    1
1                    1        1                    1
1                    1        1                    1
1                11  1        1                    1
1             111  11         1                    1
1            1       1        1                    1
1            1       1        1                    1
1           1        1        1                    1
1          1         1        1                    1
1          1         1        1                    1
1          1         1        1                    1
 1111111111 111111111          1111111111111111 1111
1                    1        1                1   1
1                    1        1               1    1
1                    1        1               1    1
 1                   1        1              1     1
1 1                  1        1             1      1
1  1                 1        1            1       1
1   1                1        1            1       1
1    1               1         1          1        1
1    1               1         1          1        1
1    1               1        1           1        1
1    1               1        1          1         1
1     1              1        1          1         1
1     1              1        1         1          1
1     1              1        1          1         1
1      1             1        1          1         1
1      1             1        1          1         1
1111111 1111111111111          1111111111 1111111111
```

Figure 5.1.—Results of thinning the example in figure 4.1 without making ADDS.

```
 11111111111111  1111        11111111  11111111111
1              11    1      1        11          1
1              1     1      1         1          1
1              1     1      1        1   111     1
1             1     1       1        1  1   1    1
1            1   111 1      1        1 1     1   1
1           1 1 1    1      1        1 1      1  1
1            1 1     1      1        1  1     1  1
1        1  1        1      1        1 1       111
1      11 11         1      1         1 1        1
1     1  1           1      1        1 1         1
1    1 11            1      1       1            1
 1  1 1              1      1       1            1
1 11   1             1      1      1             1
1     1              1      1     1              1
1    1               1       1    1              1
1   1                1      1 1111               1
1  1                 1      1     11             1
1 1                  1      1       1            1
 1 11111  11111111111        1111111 111111  11111
1       11          1       1              11    1
1        1       111 1      1               1    1
1        1     11    1      1             11     1
1        1   11      1      1          111       1
1         1 1        1      1         1          1
1          1         1      1        1           1
1         1          1      1       1 1          1
1          1         1      1       1  1      1  1
1         1          1      1        1  1 1111 111
1        1 11        1      1         11 1      11
1        1   11      1      1                    1
1        1     1     1      1                    1
1        1      1    1      1                    1
1        1      1    1      1                    1
 111111 1 111111 1111        111111111111111111111
1      1             1      1                    1
1      1             1      1                    1
1      1     111     1       1                   1
1     1     1   11111        11   1111   111111111
1     1    1         1      1  111    1 1       11
1    1     1         1       11       11 11    1 1
1    1     1         1      1        1     1111  1
1   1     1 1 1      1      1       1            1
1   1      1 1 111   1      1       1            1
1   1    11       11 1      1       1            1
1    1 11  1        1       1       1            1
1     1   1          1      1        1           1
1         1          1      1        1           1
1         1          1      1         1          1
1        1           1      1         1          1
1       1            1      1         1          1
11111111 111111111111        111111111 11111111111
```

Figure 5.2.—Results of thinning the examples in figure 4.2 without making DELETES.

```
1111111111111111111111        1111111111111111111111
1                    1        1  1                 1
1                    1        1   1                1
1                  111        1    1               1
1                111 1        1     11             1
1             111    1        1       11           1
1             11     1        1       11           1
1             11     1        1       11           1
1   1111111111       1        1         1111       1
1 11         1       1        1            11      1
111          1       1        1             11     1
1            1       1        1              11    1
1            11      1        1               1    1
1             11     1        1               1    1
1               1    1        1              1     1
1               11   1        1             11     1
1111111111111111111111        1111111111111111111111
1                    1        1            11      1
1                    1        1            11      1
1       111          1        1            11      1
1    111   1111      1        1            1       1
1  111       11      1        1            11      1
1111          1      1        1            1       1
1             1      1        1            1       1
1             1      1        1            1       1
1             1  11  1        1            11      1
1            1111  111        1            1       1
1            1       1        1            1       1
1           11       1        1            1       1
1          11        1        1            11      1
1          1         1        1            1       1
1          1         1        1            1       1
1         11         1        1            1       1
1111111111111111111111        1111111111111111111111
1                    1        1                1   1
1                    1        1               1    1
1       11111        1        1              11    1
1111  11     11      1        1             11     1
1 11 11       11     1        1            11      1
1  111         11    1        1           11       1
1   11          11   1        1           11       1
1   11           1   1        1111111111111        1
1    1           11  1        1111        1        1
1    1            11 1        1          11        1
1    1             111        1          1         1
1    11             11        1          1         1
1     1              1        1         1          1
1    11              1        1         11         1
1      1             1        1          1         1
1     11             1        1          1         1
1111111111111111111111        1111111111111111111111
```

Figure 5.3.—Results of making ADDS in the examples in figure 4.1.

```
111111111111111111111       111111111111111111111
1             11    1       1       11          1
1             1     1       1       11  111     1
1            11     1       1       1  111111   1
1           11   1111       1      11 11   111  1
1          111  111 1       1      11 1     11  1
1        111   1    1       1      11 1      11 1
1       11   11     1       1      11 11    11  1
1      11   11      1       1       1  11     111
1     11  111       1       1       11 11       1
1    11  11         1       1      111111       1
1   11  11          1       1     11  11        1
11111  11           1       1     11            1
1111  11            1       1    11             1
1    11             1       1    1              1
1   11              1       1111 11             1
1  11               1       1 11111             1
1 11                1       1   1111            1
1 1                 1       1      11           1
111111111111111111111       111111111111111111111
1      11        1111       1             11    1
1       1     11111 1       1            111    1
1      11   1111    1       1          1111     1
1      1  1111      1       1       11111       1
1      1 111        1       1      111          1
1      1 11         1       1     1111          1
1      1 1          1       1     11 11         1
1      1 11         1       1     11      11111 1
1      1 111        1       1      1111111111 111
1      1  1111      1       1       11111      11
1      11   111     1       1                   1
1      11     11    1       1                   1
1      11     11    1       1                   1
1      11     11    1       1                   1
111111111111111111111       111111111111111111111
1      1            1       1                   1
1     11    1       1       1                   1
1     11   11111111 1       1111111             1
1    11    11  111111       111111111111111111111
1    11   11        1       1  111            111
1   11    11        1       1111    1111111   1 1
1   11    11        1       1      11     11111 1
1  11    11  11111  1       1      1         1  1
1  11   111111 1111 1       1      1            1
1  11  11111     11 1       1      1            1
1  111111 11       11       1      1            1
1   111   1         1       1      11           1
1        11         1       1       1           1
1        11         1       1       11          1
1       11          1       1        1          1
1      11           1       1        1          1
111111111111111111111       111111111111111111111
```

Figure 5.4.—Results of making DELETES in the examples in figure 4.2.

```
 11111111111111111111          11 111111111111111111
1                    1        1  1                 1
1                    1        1   1                1
1                   1         1    1               1
1                111 1        1     11             1
1               1    1        1       1            1
1              1     1        1        1           1
1             1      1        1        1           1
1   1111111111       1        1         111        1
1  1         1       1        1            1       1
 11          1       1        1             1      1
1            1       1        1              1     1
1             1      1        1               1    1
1              1     1        1               1    1
1               1    1        1              1     1
1                1   1        1              1     1
 1111111111111111 111          111111111111  1111111
1                    1        1            11      1
1                    1        1             1      1
1                    1        1             1      1
1       111          1        1             1      1
1     11   11        1        1            1       1
1   11       1       1        1             1      1
 111          1      1        1            1       1
1             1      1        1            1       1
1             1      1        1            1       1
1             1  11  1        1             1      1
1             111  11         1            1       1
1            1       1        1            1       1
1            1       1        1            1       1
1           1        1        1             1      1
1          1         1        1            1       1
1          1         1        1            1       1
1          1         1        1            1       1
 1111111111 111111111          111111111111 111 1111
1                    1        1                1   1
1                    1        1               1    1
1       11111        1        1               1    1
 1     1     1       1        1              1     1
1 1   1       1      1        1             1      1
1  1 1         1     1        1            1       1
1   1           1    1        1            1       1
1    1           1   1         1  111111111        1
1    1            1  1         111        1        1
1    1             1 1        1           1        1
1    1              1         1          1         1
1     1              1        1          1         1
1     1              1        1         1          1
1     1              1        1          1         1
1      1             1        1          1         1
1      1             1        1          1         1
1111111 1111111111111          1111111111 1111111111
```

Figure 5.5.—Results of thinning the examples in figure 5.3.

```
 11111111111111  1111         11111111  11111111111
1              11    1       1        11          1
1              1     1       1         1          1
1              1     1       1        1   111     1
1             1     1        1        1  1   1    1
1            1   111 1       1        1 1     1   1
1          11   1    1       1        1 1      1  1
1        11   11     1       1        1  1     1  1
1       1    1       1       1        1   1     111
1      1   11        1       1         1  1       1
1     1   1          1       1        1 11        1
1    1   1           1       1       1            1
 1  1   1            1       1       1            1
1 11   1             1       1      1             1
1     1              1       1     1              1
1    1               1        1    1              1
1   1                1       1 1111               1
1  1                 1       1     11             1
1 1                  1       1       1            1
 1 11111  11111111111         1111111 111111  11111
1       11          1        1              11    1
1        1       111 1       1               1    1
1        1     11    1       1             11     1
1       1    11      1       1          111       1
1       1   1        1       1         1          1
1       1  1         1       1        1           1
1       1 1          1       1       1            1
1       1  1         1       1       1         1  1
1       1   1        1       1        1    1111 111
1       1    1       1       1         1111      11
1        1    1      1       1                    1
1        1     1     1       1                    1
1        1      1    1       1                    1
1        1      1    1       1                    1
 111111 1 111111 1111         111111111111111111111
1      1             1       1                    1
1      1             1       1                    1
1      1     111     1        1                   1
1     1     1   11111         11   1111111111111111
1     1    1         1       1  111              11
1    1     1         1        11       11111    1 1
1    1     1         1       1        1     1111  1
1   1     1   1      1       1       1            1
1   1      111 111   1       1       1            1
1   1    11       11 1       1       1            1
1    1 11  1        1        1       1            1
1     1   1          1       1        1           1
1         1          1       1        1           1
1         1          1       1         1          1
1        1           1       1         1          1
1       1            1       1         1          1
11111111 111111111111         111111111 11111111111
```

Figure 5.6.—Results of thinning the examples in figure 5.4.

The polygon extractor starts with a label location in the binary map. The label location is found in the POLLY program by transforming the x-y label map coordinates into row-column grid coordinates. Starting at the column of the label location, the row is scanned to the right until a line is encountered. The line is followed clockwise around the polygon. At any intersection the closest line in the counterclockwise direction is taken. The line is followed until the starting point is reached. When a deadend is encountered the last bit in the line is eliminated, and the program attempts to continue following the line. If the next bit back along the line is now a deadend it is eliminated. This backing up continues until a bit is found which can continue the line or until a fifth bit would be eliminated. When a fifth deadend bit is encountered in a string the program abandons the attempt to extract the polygon. If the program successfully returns to the starting point it creates an artificial deadend by filling in the row of the label location from the starting point to the label position. This artificial deadend is used to detect multiple labels in a single polygon.

With the operation of this algorithm in mind, we can describe the correction of the data errors signaled by the following error messages. Several of the error messages are followed by this label printout:

```
LABEL NUMBER = n, LABEL = m, X = i, Y = j MAP LABEL = kkk)
```

where:

n is the position of the label in the input card deck,
m is the position of the label in the local label list,
i, j are the label location in map coordinates,
kkk is the label.

Error messages that begin with 10 asterisks terminate processing of that polygon, while error messages with 5 asterisks are warning messages.

```
**********LABEL LOCATION OUT OF RANGE**********
```

When the x-y label location in map coordinates is converted to row-column in grid coordinates, one of the coordinates is outside of the range 1 to SCAN ROWS or SCAN COLUMNS. The label printout following this message locates the label in the card deck and on the original map so that it can be corrected.

```
*****THE FOLLOWING LABEL IS ON OR ADJACENT TO A LINE*****
```

The label location given in the label printout that follows this message may be in error. Its location near a line may also keep other errors from being detected.

```
**********REACHED EDGE OF MAP**********
```

The scan to the right has gone to the last column and has not encountered any line. The label location in the following label printout may have been misread or improperly recorded. When labeling a small polygon along the top, right, or bottom edge, a small error in either map or grid control points could put the label outside of the map perimeter.

```
POLYGON TOO LONG. STOPPED AT ROW i, COLUMN j LABEL AT ROW k COLUMN n
```

The polygon has more than the maximum number of points allowed in its border (see section 2.7). The following label printout will locate the polygon on the original map. The polygon must be cut into at least two smaller polygons by adding one bits to the binary map using correction cards. A new label must be added to the label deck for each new polygon created.

```
**********SCAN INTERRUPTED BY ISLAND**********

LABEL AT ROW i, COLUMN j
```

The polygon boundary does not enclose the label and is therefore an island inside the polygon for which the label was intended. Find the island using the label printout that follows the error message. Eliminate the island by means of correction cards.

```
*****DEADEND ENCOUNTERED*****

DEADEND AT ROW i COLUMN j X = x, Y = y,

POLYGON LABEL AT ROW i, COLUMN j
```

This is followed by a label printout and one of the three following messages. If the deadend is artificial, the left end is ear a previously used label location, that label is found and this message is printed:

```
*********THE FOLLOWING LABEL IS WITHIN 5 HUNDREDTHS OF THE DEADEND**********
```

his is followed by a label printout. The two labels are in the same polygon. They can be found in the sorted label list nd on the original map so that the conflict can be resolved. If the two labels appear to be in adjacent polygons on the ap and their label locations are correctly recorded, a gap in a line may have caused the thinning algorithm to erase e boundary between the two polygons.

If no label is found within 0.05 inch (1.27 mm) of the deadend it is assumed to be a real, not artificial, deadend. n this case a 40-row by 40-column piece of the binary map is printed. The piece is centered on the deadend. For short eadends this printout should be sufficient for correcting the error. For more complex cases, the FREQTB or BIPRIN rintout will have to be referenced. Deadends less than 5 bits long will be eliminated from the boundary by the pro-ram and need not be corrected with delete cards.

```
*********MORE THAN 4 DEADENDS**********
```

Te following message is printed and processing of this polygon is terminated when the deadend is more than 4 bits lg:

```
**********DEADEND AT BEGINNING AND END OF POLYGON**********
```

W en a second label in a polygon is on the same row as the first label, the artificial deadend is not seen as a deadend in e usual way. This message is followed by a label printout for the current label and a label printout for the label w in 0.05 inch (1.27 mm) of the deadend.

When POLLY has tried to extract a polygon for each label read in, it compares the number of labels read with th umber of polygons extracted. If these figures are not equal, the output tape is written and the run terminated. If th igures are equal and the area of the enclosing polygon is within one part in 4,000 of the sum of the areas of the en osed polygons, the output file is written and the run terminated. If, however, a polygon has been extracted for ev y label and some of the area of the map is still not accounted for or is duplicated, a second stage of processing is en red if the **CHECK HOLES** option was specified (see section 5.3). POLLY fills in the area of the binary map rep sented by each labeled polygon. It then searches the map for remaining holes. If a one-cell hole is found, a me age is printed along with the usual 40 x 40 piece of the binary map. One-cell holes are due to an error in the bir y map, which can be eliminated with correction cards. All larger holes are given the label **NEEDS LABEL** and are xtracted. If the polygon consists of less than 29 points, the 40 x 40 piece of binary map is printed because most of the small polygons are due to errors in the binary map that can be corrected. All valid polygons can be properly lab d and located in a subsequent run. If there are islands in the map, the process of filling the island and the surrounding polygon produces a hole where the island belongs. If the area of enclosed polygons exceeds the area of the enclosing polygon, each polygon labeled **NEEDS LABEL** should be checked for being an island on the map. Islands can be eliminated using correction cards.

Occasionally, due to poor quality input or careless editing, a map will have many interrelated errors. In such cases, it is sometimes difficult to find the causes of all the errors. It is best then to rerun POLLY with as many corrections as possible. Many of the remaining errors will disappear and the rest will be easier to correct.

6. PLOTTING A MAP (CHART)

CHART plots the polygons on a digital plotter, allowing a map to be checked visually. The map display consists of polygons with their identification, x and y scales in map coordinates, and a title which is an extract of the header record.

Input Cards:

1. System cards.

```
//(JOB CARD)
/PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
/ EXEC WRIS,PROG = CHART
/INPUT DD *
```

2. RID*POLY control cards.

a. **FILES:** (required) contains input tape reel number.

b. **HEADER:** (required) contains forest, map, and layer.

c. **HEADER UPDATES:** (optional) allows changes to be made in the header record for printer and plotter utput only.

d. **OPTIONS:** (optional).

SKIPS = n, causes the input tape to be positioned forward over n map-files.

e. **POLYGON SELECTIONS:** (optional). This section is used to select a subset of polygons from the input iap-file (see section 2.3.2.9).

f. **PLOT OPTIONS:** (optional) allows user to specify the following options:

i. **MAGNIFICATION =** factor; this is the amount of blow-up or reduction to be made on the plotted ıtput. The default value is a factor of 1.0.

ii. **PLOT CONTROL POINTS:** this option is used to plot hash marks at each map control point location. he default is to plot only the map control points which fall in the area selected to be plotted.

iii. This section is used to specify how a polygon is to be identified on the plotted output. Polygons can be entified by either one of the following methods:

PLOT ITEM NUMBERS; each polygon in a map-file is assigned a unique number, refered to as an **IEM NUMBER**. If this option is specified, each polygon will be plotted with its item number as the label.

PLOT LABELS; if this option is specified, each polygon will be plotted with the label assigned to it by t POLLY program.

PLOT LABEL NUMBERS; each unique label in a polygon map-file is assigned a number, referred to a the **LABEL NUMBER**. If this option is specified, each polygon will be plotted with its corresponding label number.

PLOT NO POLYGON ID; this option is used to plot polygons without any identification.

The default is to **PLOT ITEM NUMBERS**.

iv. **PLOT PERIMETER POLYGON;** this option is used to plot the perimeter polygon. The default is to exclude the perimeter polygon.

The perimeter polygon is useful for orientation, particularly when a subset of polygons is selected via the **POLYGON SELECTION SECTION**. Unless the **PLOT PERIMETER POLYGON** option is specified, only the portion of the map large enough to encompass the selected polygons is plotted. If **POLYGON SELECTIONS** and **PLOT PERIMETER POLYGON** sections both are specified, the user must be careful not to exclude the perimeter polygon in the **POLYGON SELECTION SECTIONS**. For example: **POLYGON SELECTIONS: INCLUDE ITEMS = 25, 26,79:209,290$ PLOT OPTIONS: PLOT PERIMETER POLYGON$** would not result in the perimeter polygon being plotted because the perimeter polygon (item number 1) was excluded by the **POLYGON SELECTION SECTION**. The correct way is: **POLYGON SELECTIONS: INCLUDE ITEMS = 1,25,26,79:209,290$ PLOT OPTIONS: PLOT PERIMETER POLYGON$**

v. **THINNING TOLERANCE = X;** this option is used to reduce the number of x-y coordinates that will be plotted in the perimeter of a polygon. Specifying a thinning tolerance will reduce plotting time; however, it will also reduce polygon resolution.

The variable X is a floating point number and has a default value of 0.0 (which means no thinning is done).

vi. **EXCLUDE BOUNDARIES;** this option is used to eliminate the polygon boundaries on the plotted output. The map plotted will contain polygon ID's, control points, and the perimeter polygon if it exists on the input file. The default is to plot polygon boundaries.

Sample Input Deck:

```
//JOB (,,30),CHART,MSGLEVEL = (1,1),TIME = 2
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// EXEC WRIS,PROG = CHART
//INPUT DD *
FILES: INPUT = WRIS01$
HEADER: FOREST = ST.JOE;MAP = 113; LAYER = LAND USE$
OPTIONS: SKIPS = 3$
HEADER UPDATES: FOREST = ST.JOE; MAP = 113; LAYER = LAND USE;
LOCATION = TENSED$
PLOT OPTIONS: MAGNIFICATION = .85$
```

See appendix F.2 for the actual execution of this job stream.

7. OVERLAYING MAPS (MOSAIC)

MOSAIC overlays two maps representing the same geographic area. The result is a polygon map-file in which each polygon represents the area common to a pair of polygons, one from each input map-file. (In mathematical erms, this overlay is the **intersection** of the sets of points inside the two input polygons.) The label of this new polygon is a concatenation of the two constituent labels separated by an "&". (For example, if the two constituent abels are PP/AGSP and 99*01*55, then the concatenated label would be PP/AGSP&99*01*55.)

If the label of the new polygon contains more than 36 characters, it will be truncated to 36 characters. This label concatenation process will continue for each successive overlay. All such pairs of overlapping input polygons are processed. If both input map-files completely cover a given geographical area with polygons, so will the resulting map-file. "Slivers," or polygons of insignificant size, are disregarded. The user can specify the minimum sliver size, minimum nput polygon size, and the minimum output polygon size. (See MOSAIC OPTIONS, section 7.2.i).

Polygons from either of the input map-files can be selected or excluded from the overlay process by using the conentions described in section 2.3.2.9.

The resultant map-file can be written to tape for later use. If the output map-file is not needed, only a table of creages showing the total area for each label pair can be produced.

Multiple overlays can be run in a single job by including a set of RID*POLY control cards for each overlay to be erformed (see section 7.2.j).

put Cards:

1. System cards. (required)

```
JOB CARD)
PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
EXEC WRIS,PROG = MOSAIC
NPUT DD *
```

2. RID*POLY control cards.
   a. **FILES:** (required)

   Contains input and output tape reel numbers.

   INPUT ONE = nnnnnn;- tape volume serial number of first map-file.

   INPUT TWO = mmmmmm;- tape volume serial number of second map-file.

   OUTPUT = kkkkkk;- tape volume serial number of resultant map-file.

   Specify **OUTPUT = NONE** if the resultant map-file is not wanted.

   b. **HEADER ONE:** (required)

   Used to select the first map-file for processing. **FOREST, MAP**, and **LAYER** must be specified.

   c. **OPTIONS:** (optional)

   SKIPS = n; causes the first input tape to be positioned forward over n map-files.

   THINXY = X; (for first map-file)

This option is used to specify a thinning factor for the polygon perimeter thinning routine. X is a floating point number with a default value of 2.0.

The **THINXY** option should be used only to correct the **INCOHERENT OVERLAY** error message because it significantly increases MOSAIC processing time. The smaller the value of X, the fewer points will be thinned from a polygon perimeter. Generally a value of 1.75 will resolve the incoherent overlay problem.

d. **POLYGON SELECTIONS:** (optional)

This section is used to select a subset of polygons from the first map-file. Unwanted polygons can be deleted in this section. (See section 2.3.2.9.)

e. **HEADER TWO:** (required)

Used to select the second map-file for processing. **FOREST, MAP**, and **LAYER** must be specified.

f. **OPTIONS:** (optional)

SKIPS = n; causes the second input tape to be positioned forward over n map-files.

THINXY = X; (for second map-file). See section 7.2.c for description.

g. **POLYGON SELECTIONS:** (optional)

This section is used to select a subset of polygons from the second input map-file. Unwanted polygons can be deleted in this section. (See section 2.3.2.9.)

h. **OUTPUT HEADER:** (required)

This section is used to specify header information for the output map-file that differs from the input map-files, namely, **FOREST, MAP**, and **LAYER**.

i. **MOSAIC OPTIONS:**

MINIMUM INPUT POLYGON AREA = X;

This option is used to specify the minimum area which polygons from the input map-files may contain. Polygons that have areas less than the specified value of X will be excluded from the overlay process.

The variable X is a floating point number representing acres. The default value is 5.0 acres.

The **MINIMUM INPUT POLYGON AREA** option is used to screen polygons from both input map-files. If the user wishes to screen the input map-files separately, then the **INCLUDE AREAS GREATER THAN** or **EXCLUDE AREAS GREATER THAN** options of the **POLYGON SELECTION** section should be used. However, the **MINIMUM INPUT POLYGON AREA** takes precedence, therefore, the user must set its value lower than the values of the **INCLUDE** or **EXCLUDE** options.

For example:

```
FILES: INPUT ONE = CC3930; INPUT TWO = CC7183; OUTPUT = CC6404$
HEADER ONE: FOREST = ST.JOE; MAP = 33; LAYER = HABITAT$
OPTIONS: SKIPS = 4$
POLYGON SELECTIONS: INCLUDE AREAS GREATER THAN = 15.0$
HEADER TWO: FOREST = ST.JOE; MAP = 30; LAYER = STAND$
OPTIONS: SKIPS = 1$
POLYGON SELECTIONS: INCLUDE AREAS GREATER THAN 5.00$
OUTPUT HEADER: MAP = 33; LAYER = HABITAT/STAND$
MOSAIC OPTIONS: MINIMUM INPUT POLYGON AREA = 0.0$
```

In the above example, the minimum acceptable polygon size is 15 acres for the first map-file and 5 acres for the second map-file. The **MINIMUM INPUT POLYGON AREA** value was set to 0.0 acres so that it would not override the previous selections.

MINIMUM OUTPUT POLYGONS AREA = X;

This option is used to select a minimum size for output polygons. Polygons, constructed during the overlay proc-ss, which have areas less than the value of X will be excluded from the tabular output and the output polygon map-ile.

The variable X is a floating point number representing acres. X has a default value of 5.0 acres.

MINIMUM MAP SLIVER WIDTH = X1;
or
MINIMUM GROUND SLIVER WIDTH = X2;

A sliver is a polygon of insignificant size, generally long and narrow, which is produced when polygon boundaries lmost coincide.

Either of these options is used to specify the minimum width a polygon may have. If the width of a polygon is less ian the specified value of X1 or X2, then the polygon is a sliver and will be excluded from the tabular listing and olygon output map-file.

The minimum sliver width should be specified in either ground or map measurements, but not both. Ground idth represents the actual distance a polygon covers on the ground and must be specified in feet. Map width is the stance the polygon width covers on the map and must be specified in inches.

For example, if the area within 250 feet of a stream is of interest to a user, then MINIMUM GROUND SLIVER IDTH = 250.0; should be specified. However, if the actual ground distance is not known, then a minimum accept-le width should be selected from the map, for example MINIMUM MAP SLIVER WIDTH = .04;

The default value for sliver width is calculated by: sliver width = 0.04 * map scale/12.0. For example, 0.04 * 16720.0/12.0 = 422.40 feet.

j. **END$** (optional)

Signals the end of RID*POLY control sections for the current map. This section must be included if control sec-tns for another map follow.

mple Input Deck:

```
//OB (,,50),MOSAIC,MSGLEVEL = (1,1),TIME = 5
//ROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// XEC WRIS,PROG = MOSAIC
// PUT DD *
F ES: INPUT ONE = WIRS01; INPUT TWO = WRIS01; OUTPUT = NONE$
 ADER ONE: FOREST = ST.JOE; MAP = 59; LAYER = HABITAT;
S TE = IDAHO;ZONE = 3$
 TIONS: SKIPS = 3$
H ADER TWO: FOREST = ST.JOE; MAP = 113; LAYER = LAND USE;
S TE = IDAHO;ZONE = 3$
O TIONS: SKIPS = 3$
P LYGON SELECTIONS: INCLUDE AREAS GREATER THAN = 5.09$
O TPUT HEADER: FOREST = ST.JOE;LAYER = HABITAT/LAND USE;MAP = 113;
L CATION = TENSED,
S TE = IDAHO; ZONE = 3$
M SAIC OPTIONS: MINIMUM INPUT POLYGON AREA = 2.0;
                MINIMUM OUTPUT POLYGON AREA = 1.0;
                MINIMUM GROUND SLIVER WIDTH = 150.0$
```

See appendix F.5 for the actual execution of this job stream.

8. COMBINING POLYGON MAP-FILES (MERGE)

MERGE combines two polygon map-files into one map-file. This routine was developed to aid in the polygon extraction process (POLLY). Generally, the first pass through POLLY will result in the extraction of the majority of polygons. However, if all polygons are not extracted successfully, corrections must be made and POLLY rerun on the entire map until all errors are resolved. This process may become expensive on large maps or on maps that require several POLLY runs. Thus, the following procedure can be used to reduce the processing required to produce a final map-file:

1. Run the first POLLY and save the polygon output map-file.
2. Make the necessary corrections and rerun POLLY, using **only** the polygon labels that were not extracted in the first POLLY run. Repeat this step until all errors are resolved.
3. After all errors have been resolved in Step 2, the MERGE routine should be used to combine the polygon map-files from Steps 1 and 2 to produce a complete polygon map-file.

Caution must be used in the merging procedure discussed in the previous section. Since polygons are extracted in two separate runs (Step 1 and Step 2), duplicate labels within a polygon cannot be detected between the two runs. The polygons in Step 2 should be edited carefully to avoid duplicate labels. The MERGE routine will print a total area figure for all polygons contained in the output map-file. This figure should be compared to the area of the perimeter olygon. If the total area figure is greater than the perimeter polygon area, there are duplicate labels within a polygon. If the total area figure is less than the area of the perimeter polygon, then some polygons have been missed in the exraction process. In either case, CHART can be used to produce a visual display to resolve discrepancies.

The perimeter polygon for the output map-file will be selected from one of the input map-iles have a perimeter polygon, the perimeter polygon from the first map-file will be selected automatically. If the erimeter polygon from the second map-file is wanted, the **POLYGON SELECTION** section should be used to delete he perimeter polygon from the first map-file.

To reduce processing time and cost, the first map-file in MERGE should contain the largest of the two map-files. enerally this map-file will be the polygon map-file produced by Step 1 of the procedure discussed above.

nput Cards:

1. System cards. (required)

```
(JOB CARD)
PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
 EXEC WRIS,PROG = MERGE
 NPUT DD *
```

2. RID*POLY control cards.

a. **FILES:** (required) Contains input and output tape reel numbers.

INPUT ONE = nnnnnn; - tape volume serial number of first map-file.

INPUT TWO = mmmmmm; - tape volume serial number of second map-file.

OUTPUT = kkkkkk; - tape volume serial number for output map-file. Specify **OUTPUT = NONE;** if the resultant map-file is not to be saved.

b. **HEADER ONE:** (required)

Used to select the first map-file for processing. **FOREST, MAP**, and **LAYER** must be specified.

c. **OPTIONS:** (optional)

SKIPS = n; causes the first input tape to be positioned forward over n map-files.

d. **POLYGON SELECTIONS:** (optional)

This section is used to select a subset of polygons from the first input map-file. Unwanted polygons can be deleted in this section. (See section 2.3.2.9.)

e. **HEADER TWO:** (required)

Used to select the second map-file for processing. **FOREST, MAP**, and **LAYER** must be specified.

f. **OPTIONS:** (optional)

SKIPS = n; causes the second input tape to be positioned forward over n map-files.

g. **POLYGON SELECTIONS:** (optional)

This section is used to select a subset of polygons from the input map-file. Unwanted polygons can be deleted in this section. (See section 2.3.2.9.)

h. **OUTPUT HEADER:** (optional)

This section is used to specify header information for the output map-file, which differs from the input map-files, namely, **MAP** and **LAYER**. If this section is not included, the output header record will be built automatically from the two input map-files.

Sample Input Deck:

```
//JOB (,,50),MERGE,MSGLEVEL = (1,1),TIME = 2
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// EXEC WRIS,PROG = MERGE
//INPUT DD *
FILES: INPUT ONE = WRIS01; INPUT TWO = WRIS01$
HEADER ONE: FOREST = ST.JOE; MAP = 59; LAYER = HABITAT$
OPTIONS: SKIPS = 3$
HEADER TWO: FOREST = ST.JOE; MAP = 113; LAYER = LAND USE$
OPTIONS: SKIPS = 3$
OUTPUT HEADER HEADER: FOREST = ST.JOE;LAYER = LAND USE;MAP = 113$
```

9. MISCELLANEOUS MAP-FILE CORRECTIONS (TONIC)

TONIC allows various corrections and changes to be made to be polygon map-file.

nput cards:

1. System cards.

```
JOB CARD)
PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
EXEC WRIS,PROG = TONIC
NPUT DD *
```

2. RID*POLY control cards.

a. **FILES:** (required)

Contains input and output file names.

INPUT = mmmmmm; - tape volume serial number of the polygon input map-file.

OUTPUT = nnnnnn; - tape volume serial number on which the corrected polygon map-file is to be written. I he output map-file is not wanted, specify **OUTPUT = NONE;**.

b. **HEADER:** (required)

This section is used to select a polygon map-file for processing. **FOREST**, **MAP**, and **LAYER** must be specified.

c. **OPTIONS:** (optional)

SKIPS = n; causes the input tape to be forward spaced n map-files.

d. **HEADER UPDATES:** (optional)

This section is used to make corrections or additions to the header record.

e. **POLYGON SELECTIONS:** (optional)

This section is used to select a subset of polygons from the input map-file. Unwanted polygons can be deleted in tl section. (See section 2.3.2.9.)

f. **LABEL COMBINATIONS:** (optional)

This section is used to aggregate two or more labels under a new label. The format for combining labels is 'l el = list of labels'. The new label is specified on the left-hand side of the ' = ' sign. This label will be assigned to all p gons that have a label matching a label specified in the list on the right-hand side of the ' = ' sign. The label list (r nt-hand side) is a list of labels separated by commas and terminated with a simicolon. The last label combination se hould be terminated by a dollar sign to signify the end of the **LABEL COMBINATIONS** section. A new label (le -hand side) cannot appear on the right-hand side of any label combination. Labels in the list of labels (right-hand si) should not appear in a list of labels (right-hand side) of another label combination. For example, **LABEL COMBI ATIONS: 500 = 510,520,530$**

This section can be used also to change labels. For example, the label **STATE** can be changed to **STATE LAND** by e following control card:

LABEL COMBINATIONS: STATE LAND = STATE$

g. NEW LABELS: (optional)

This section is used to relabel individual polygons. The format is 'item number, new label'. The new label is assigned to the polygon with the specified item number. Each entry is separated by a semicolon and the last entry is terminated with a dollar sign (NEW LABELS: 2,SPRUCE;6,GRAND FIR;20,CEDAR$).

h. NEW LABELS BY LOCATION: (optional)

This section is used to assign a new label to a polygon by specifying its label coordinates. (The label coordinates of a polygon can be obtained from a POLLY, CHART, or MOSAIC job listing.) Its format is LABEL x y,. The x and y coordinates should be specified without decimal points. Each entry should be followed by a comma and the last entry should be terminated with a dollar sign.

i. NEW LABEL LOCATIONS: (optional)

This section is used to change a polygon's label location. The format is 'item number, x,y'. The polygon specified by the item number will have its label moved to the specified x-y coordinates. If x and y are zero, the label location will be computed automatically. The x and y coordinates should be specified without decimal points. Each entry should be followed by a semicolon and the last entry should be terminated with a dollar sign.

j. STORE ACREAGES$ (optional)

This section is used to produce a list of labels and their corresponding acreages. The output consists of a computer printout and a deck of cards. The card deck is used by the RID*POLY routine TALLY to provide tabulations of acreage figures. This deck can be put on tape or disk by changing the //FT07F001 JCL statement. (See the programer responsible for maintaining RID*POLY at your installation.)

NOTE: This section contains no entries, thus STORE ACREAGES is followed by a dollar sign.

Sample Input Deck:

```
// JOB (,,45),TONIC,MSGLEVEL = (1,1),TIME = 2
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// EXEC WRIS,PROG = TONIC
//INPUT DD *
FILES: INPUT = WRIS01; OUTPUT = NONE$
HEADER: FOREST = ST.JOE; MAP = 59; LAYER = HABITAT$
OPTIONS: SKIPS = 3$
HEADER UPDATES: FOREST = ST.JOE; MAP = 59; LAYER = HABITAT;
LOCATION = TENSED$
LABEL COMBINATIONS: 500 = 410,520,530$
NEW LABELS: 2,PVT; 3,880$
NEW LABELS BY LOCATION: 999 1487 1417, 998 339 1138$
NEW LABEL LOCATIONS: 4,1480,1410; 11,340,1140$
```

See appendix F.8 for the actual execution of this job stream.

10. UNIVERSAL DATA EXCHANGE FORMAT (XCHG)

A universal data exchange format has been designed to facilitate the transfer of information between polygon-ased geographical information systems within the Forest Service. The RID*POLY program XCHG will convert a RID*POLY polygon map-file into the universl data exchange format. (See appendix B.4 for exchange format.)

The following system and RID*POLY control cards are required to execute XCHG:

1. System cards.

```
/(JOB CARD)
/PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
/ EXEC WRIS,PROG = XCHG,TAPEOUT = mmmmmm,FILENUM = m1,
/NAME = location.layer
INPUT DD *
```

here:

<u>mmmmmm</u> is the volume serial number of the tape on which the universal data exchange information will be ritten.

<u>m1</u> is the file position on the output tape.

<u>location.layer</u> is the name that will be assigned to the data exchange file. This name should contain information hich will identify the file, such as location and layer separated by a '.', for example, **HAUGAN.HABITAT**. This me must not contain any special characters.

2. RID*POLY control cards.

The following list contains all possible control sections for the XCHG program. (Refer to chapter 2 for more in-mation on a specific control section.)

a. **FILES:** (required)

This section is used to select the input tape.

b. **HEADER:** (required)

This section is used to select the polygon map-file from the input tape. **FOREST**, **MAP**, and **LAYER** must be specified.

c. **HEADER UPDATES:** (optional)

This section is used to make changes to the header record. Any changes made in this section will appear on the computer printout and the universal exchange output, if applicable.

d. **(OPTIONS)** (optional)

This section is used to select any of the following options:

SKIPS = n; where n represents the number of map-files to skip on the input tape.

TRIM; This option will orient the polygon map-file such that the minimum x and y coordinates are 1. The default value is **TRIM**.

NOTRIM; This option will not reorient the x and y coordinates from the polygon map-file.

NOLABELS; This option will suppress label information from being written to the data exchange file. The default is to write label information.

e. **POLYGON SELECTIONS:** (optional)

This section is used to select a subset of polygons from the input map-file (see section 2.3.2.9).

f. **END$** (required for multiple jobs)

This section is used to signal the end of control sections for the map currently being processed.

Sample Input Deck:

```
//JOB (,,35),XCHG,MSGLEVEL = (1,1),TIME = 2
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// EXEC WRIS,PROG = XCHG
//WRIS.FT11F001 DD SYSOUT = A
//INPUT DD *
FILES: INPUT = WRI$01$
HEADER: FOREST = ST.JOE;LAYER = HABITAT;MAP = 59$
HEADER UPDATES: FOREST = ST.JOE;LAYER = HABITAT;MAP = 59;
LOCATION = TENSED$
OPTIONS: SKIPS = 3$
POLYGON SELECTIONS: INCLUDE ITEMS = 2:8$
```

See appendix F.9 for the actual execution of this job stream.

11. RID*POLY TO RID*GRID CONVERSION (PGRID)

The PGRID routine converts a RID*POLY polygon map-file into the RID*GRID format. Input for PGRID onsists of RID*POLY control cards and a standard RID*POLY polygon map-file. Output from PGRID consists of a nagnetic tape file containing RID*GRID "D,E, and F" cards, a magnetic tape file containing labels and a printed summary (see flowchart 0.2). See appendix B.5 for output tape formats.

The following system and RID*POLY control cards are needed to execute the PGRID routine:

1. System cards.

```
/(JOB CARD)
/PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
' EXEC WRIS,PROG = PGRID,TPOUT#1 = nnnnnn,FILE#1 = n1,
'NAME#1 = 'name',TPOUT#2 = mmmmmm,FILE#2 = m1,NAME#2 = 'name1'
 INPUT DD *
```

here:

nnnnnn is the volume serial number of the tape on which the RID*GRID D,E, and F cards will be written.

n1 is the position of the file on the output tape.

'name'* is an ID that will be assigned to magnetic tape file n1. This name should contain information which will entify the file, for example, HAUGAN.HABITAT.GRID.

mmmmmm is the volume serial number of the tape on which the labels will be written.

m1 is the position of the file on the output tape.

'name1'* is an ID that will be assigned to the magnetic tape file m1. This name should contain information which l identify the label file, for example, HAUGAN.HABITAT.GRID.LABELS.

* OTE: name and name1 must follow the IBM dataset naming conventions.

2. RID*POLY control cards.

The following list contains all possible control sdections for the PGRID routine. (Refer to chapter 2 for a full explanation of each item.)

a. **FILES:** (required)

This section is used to identify the input tape.

b. **HEADER:** (required)

This section is used to select the input polygon map-file. **FOREST, MAP,** and **LAYER** must be specified.

c. **OPTIONS:** (optional)

This section is used to select the following option:

SKIPS = n; where n represents the number of map-files to skip on the input tape

d. **POLYGON SELECTIONS:** (optional)

This section is used to select a subset of polygons from the input map-file (see section 2.3.2.9).

The first polygon on a RID*POLY polygon map-file is usually a perimeter polygon, which is a special polygon tha encompasses all others. This polygon is not used by RID*GRID; therefore, it is automatically deleted by PGRID if o e exists. If the perimeter polygon is required, it can be renamed (by the TONIC routine) and it will not be del ed.

e. **END$** (required for multiple jobs)

This section is used to signal the end of control sections for the map currently being processed. If multiple jobs are exe uted; all RID*GRID output will be written onto the same tape file (logical unit 11) and all label information will be itten onto another tape file (logical unit 13).

Sample Input Deck:

```
//JOB (,,50),PGRID,MSGLEVEL = (1,1),TIME = 2
//PROCLIB DD DSN = GINDX.Y1978.USFS.PROCLIB,DISP = SHR
// EXEC WRIS,PROG = PGRID
//WRIS.FT11F001 DD SYSOUT = A
//WRIS.FT13F001 DD SYSOUT = A
//INPUT DD *
FILES: INPUT = WRIS01$
HEADER: FOREST = ST.JOE; MAP = 59; LAYER = HABITAT$
OPTIONS: SKIPS = 3$
POLYGON SELECTIONS: INCLUDE ITEMS = 2:8$
```

See appendix F.6 for the actual execution of this job stream.

APPENDIX A. RID*POLY PROCEDURE

```
//WRIS          PROC   DSN = 'WRIS.MAPS' ,FILENUM = ,
                       TPOUT#1 = ,FILE#1 = ,NAME#1 = NULLFILE,
                       TPOUT#2 = ,FILE#2 = ,NAME#2 = NULLFILE
//************************************************
//*                    GENERAL WRIS PROCEDURE  *
//************************************************
//              EXEC   PGM = &PROG,REGION = 900K
//STEPLIB         DD   DSN = GINDX.Y1978.WRIS.LOADLIB,DISP = SHR
//FT03F001        DD   DSN = GINDX.Y1978.WRISDRUM,DISP = OLD
//FT04F001        DD   DUMMY
//FT05F001        DD   DDNAME = INPUT
//FT06F001        DD   SYSOUT = A
//FT07F001        DD   SYSOUT = A,DCB = (RECFM = FB,LRECL = 80,BLKSIZE = 800)
//FT08F001        DD   DSN = GINDX.Y1978.WRIS.SPLANE,DISP = SHR,DCB = BUFNO = 1,
//                     UNIT = (,,DEFER)
'/FT11F001        DD   VOL = SER = &TPOUT#1,LABEL = (&FILE#1,SL,,OUT),
'/                     DSN = &NAME#1,
 /                     DCB = (BUFNO = 1,RECFM = FB,LRECL = 80,BLKSIZE = 8000),
 /                     UNIT = (TAPE,,DEFER),DISP = (,KEEP)
/FT13F001         DD   VOL = SER = &TPOUT#2,LABEL = (&FILE#2,SL,,OUT),
 '                     DSN = &NAME#2,
 '                     DCB = (BUFNO = 1,RECFM = FB,LRECL = 80,BLKSIZE = 8000),
 '                     UNIT = (TAPE,,DEFER),DISP = (,KEEP)
 TAPEIN           DD   DSN = &DSN,UNIT = (TAPE,,DEFER),
                       DCB = BUFNO = 1,LABEL = (1,SL),VOL = SER = C99999,DISP = OLD
 TAPEOUT          DD   UNIT = (TAPE,,DEFER),LABEL = (&FILENUM,SL),
                       DISP = (,KEEP),VOL = SER = CC0000,
                       DCB = (BUFNO = 1,RECFM = FB,LRECL = 6000,BLKSIZE = 6000)
 PLOTTERC         DD   DUMMY
```

APPENDIX B. DATA FORMATS

B.0 Manual Digitizer Input to WRIS

One of the WRIS programs (HANDY) accepts manually digitized map data as an alternative to the preferred method of digitizing maps by automatic scanning. There are many devices for manual digitizing, which raises the danger of proliferating different formats for the manual data and also WRIS routines for reading the tapes containing the manual data. To prevent confusion we offer a standard format for the tapes. Today's digitizers contain microprocessors to control the formatting of their output; we presume they can be programed to produce this standard format. If not, the digitizer output will have to be computer processed into this standard format.

The WRIS User's Guide section on HANDY is required reading to understand the digitizing method.

The tape is written in ASCII code. Block size is fixed, but fixed at whatever length is efficient for the digitizer being used. A logical record does not correspond to a block. The digitizer should write an end-of-block gap (about 0.75 nch) whenever the block size has been reached, and then go on to the next block to continue the logical record.

A logical record represents an arc on the map consisting of a series of connected straight line segments recorded by moving the cursor over them on the map. The next logical record starts when you move the cursor, without record-ng, to another separate arc on the map and begin recording it.

The unit of measurement on the map is 0.01 inch. Digitizer output is in integer multiples of that unit. All coor-inates must be positive.

The first character in a logical record gives its **mode**. That is, it tells whether the record is in ''point mode'' or increment mode''. In point mode the digitizer records a series of x-y coordinates. In increment mode it records an y point and follows that with a series of x and y increments from that starting point. The mode character is 1 for point mode, 2 for increment mode.

In **point mode**, there follows after the mode character a series of x-y coordinate pairs. x requires four digits and does y. After a series of such x-y pairs, a ''zero'' point is recorded to indicate end-of-record. To record x = 0 and y = 0 will require eight zeroes since it must be in the same format as a real x-y pair.

In **increment mode** the mode character is also followed by an x-y coordinate pair, to establish a starting point. he coordinate pair is followed by a series of digit pairs, each pair consisting of an increment digit for x and one for y. hus an increment may range from 0 to 9 units. One or the other must be nonzero, however, because if both are zero, that indicates the end of a logical record; that is, a pair of zeroes is end-of-record in increment mode.

Following the end-of-record indication in either mode, the next record begins with its mode character in the next character position. The end of the tape is indicated by a mode character 9.

1 Scanner Data Formats

B.1 SCANDIG Binary Output

The first block on a SCANDIG binary tape contains 92 8-bit ASCII codes. The format is:

0000	I4
sequence number	I4
forest	A24
layer	A24
map	I4
bits/pixel	I4
scan line length	I4
number of scan lines	I4
threshold value	I4
increment	I4
x length	I4
y offset	I4
y length	I4

The second and succeeding blocks contain map information in binary form (a ''1'' representing polygon boundaries and a ''0'' representing the area inside a polygon). Each block contains as many complete scan lines as will fit in a 6000-byte buffer.

B.1.2 PASEDENA PDS 1010A Density Format

The PASEDENA PDS 1010A scanner produces a density tape that is processed by the FREQTB program, version FREQ1. Each record within a file contains 96 bytes of scanner information and 2*n bytes of density readings (n is the number of scan positions across a map).

The number of scan positions is calculated once, because it does not change within a file. The number of scan positions is calculated as follows:

1. Concatenate low order 6 bits of bytes 83 and 84 to produce a 12 bit binary number, namely, byte 83 = 101101_2 and byte 84 = 110110_2 concatenated produces 101101110110_2 (2936_{10}).
2. Subtract the 12 bit binary number from 4096 to get the number of scan columns.

The density values are produced by concatenating the 5 low order bits of the first byte with the high-order bit from the second byte to produce a 6 bit binary number. This binary number is the density reading for a given scan position. For example, if byte one = 110101_2 and byte two = 100111_2, then the density value would be 101011_2 or 43_{10}.

The number of scan rows is equivalent to the number of records in the file. Thus, the density readings should be processed row-by-row until an end-of-file is encountered.

B.2 Binary Map-File Format (MODE 1)

The BIPRIN program uses FREQTB output or binary data (from the SCANDIG scanner or a previous BIPRIN run) as input and produces a binary map-file. A BIPRIN binary map-file is written in the following format.

Item	Length (words)	Contents
NWTOT	1	Total number of words in the map-file.
NH	1	Number of words in header record.
HED	NH	Header record.
NL	1	Number of words in label array (always 3 for BIPRIN).
LBL	NL	Label record (dummy array occupying 3 full words).
NI	1	Number of words in the INDEX (equivalent to the scan rows in a map).
INDX	NI	Index, containing the length of each scan row.
S_1	INDX(1)	First scan row.
S_2	INDX(2)	Second scan row.
.		
.		
.		
S_{NI}	INDX(NI)	Last scan row.
IOTA	10	IOTA array, dummy array of 10 words (not used in IBM version).

A binary map-file in this format can be recycled through BIPRIN for further editing or it can be used as input for the polygon extraction program (POLLY).

B.3 Polygon Map-File Format (MODE 2)

All polygon map-files produced by POLLY and used by CHART and MOSAIC are written in the following ormat:

Item	Length (words)	Contents
NWTOT	1	Total number of words in the map-file.
NH	1	Number of words in the header record.
HED	NH	Header record.
NL	1	Number of words in the label record.
LBL	NL	Label record. (sec. B.3.1)
NI	1	Number of words in the polygon index.
INDX	NI	Polygon index, contains the length of each polygon stored in the file.
Z_1	INDX(1)	First polygon record. (sec. B.3.2)
Z_2	INDX(2)	Second polygon record.
.		
.		
.		
Z_{NI}	INDX(NI)	Last polygon record.
IOTA	10	IOTA array, not used for anything in the IBM version.

.3.1 Label Record Format

The label record in a polygon map-file contains a list of labels which are referenced by the polygon records. The bel record is in the following (packed) format:

Item	Description
NW	# of words to follow in label record.
NUMLAB	# of labels.
LOCLAB(NUMLAB)	LOCLAB(J) is the character position of the last character of the Jth label.
LABELS(N)	Character array containing the labels, (N = NW – 1 – NUMLAB).

B.2 Polygon Record Format

Each polygon record contains a FAX record, which describes certain attributes of a polygon, and the x-y coor- d ates of the polygon perimeter. To conserve space, the FAX record and x-y coordinates are stored in packed format. T e coordinates are stored with a x and y coordinate in one word of storage (each occupies a half word - 16 bits). The F X record is stored in the following format:

Packed format *(stored)*	**Unpacked format** *(usable)*
FAX(1) = POLYGON SEQ.NO; POLYGON TYPE	FAX(1) = POLYGON SEQ. NO
FAX(2) = POLYGON AREA	FAX(2) = POLYGON TYPE
FAX(3) =	FAX(3) = POLYGON AREA
FAX(4) = POLYGON LENGTH	FAX(4) =
FAX(5) = POLYGON LABEL INDEX	FAX(5) = POLYGON LENGTH
FAX(6) = X CO-ORD; Y CO-ORD OF LABEL	FAX(6) = POLYGON LABEL INDEX
FAX(7) = MIN X; MIN Y	FAX(7) = X CO-ORD OF LABEL
FAX(8) = MAX X; MAX Y	FAX(8) = Y CO-ORD OF LABEL
FAX(9) =	FAX(9) = MIN X
	FAX(10) = MIN Y
	FAX(11) = MAX X
	FAX(12) = MAX Y
	FAX(13) =
	FAX(14) =

B.4 Universal Data Exchange Format

The Universal DATA EXCHANGE Format was designed as a means of transferring data from one computer to another without costly conversions.

Even though card image form is not the most efficient, it is universally acceptable. The information accounted for by this format is: (1) header information, which consists of literal and descriptive information about the work area; (2) control information, which is the user identified control for the data; (3) label information for identification of the pertinent digitized data; and (4) point, line, and polygon information for individual polygons. The header information is contained on two cards and the control information is two records per card and as many cards as required to complete the control list. Label information is three records per card and as many cards as necessary to complete the list. Point, line, and polygon information is recorded on two cards; the first showing pertinent individual data string characteristics and the second giving the x and y values for points on the string. Ten coordinates per card and as many cards as required will be accepted as one data string.

Header Information - Record Type 1a

Columns	Field description	Format
1-36	Forest name	9A4
37-45	Compartment-Location	2A4,A1
46-80	Layer name or names	8A4,3A1

Descriptive Information - Record Type 1b

Columns	Field description	Format
1-6	Number of polygons (strings)(1)	I6
7-12	Number of unique labels(2)	I6
13-18	Scale (reference fraction)(3)	I6
19-24	Number of control points(4)	I6
25-48	Layer envelope (X-Y/Min-Max)(5)	4I6
49-54	Area in 0.01 in^2 units	I6
55-60	Number of layers overlaid	I6
61-66	Originating system name	A6

(1) Must equal the number of record type 4a cards.

(2) Must equal the number of labels (3/card) on record type 3 cards.

(3) Denominator of scale (1/24,000 map = 24000).

(4) Must equal the number of points (2/card) on record type 2 cards.

(5) MIN and MAX X-Y of all polygons, excluding control points.

*NOTE: All records are in card image (i.e., 80 characters per record in length) and are blank filled when not used. This format is used to transmit data on tape between computers.

Control Information - Record Type 2

Columns	Field description	Format
1-6	Map x-coordinate	I6
7-12	Map x-coordinate	I6
13-22	Latitude (decimal degrees)-(0.00001 degree units)	I10
23-32	Longitude (decimal degrees)-(0.00001 degree units)	I10
33-38	Map x (next point)	I6
39-44	Map y (next point)	I6
45-54	Latitude	I10
55-64	Longitude	I10

The number of control points must agree with the number specified in column 19-24, and Record Type 1a. When lumn 19-24 in Record Type 1a is zero, this record type does not exist; when it is not zero, two control points are tered per card.

Label Information - Record Type 3

Columns	Field description	Format
1-24	LABEL	6A4
25-48	LABEL	6A4
49-72	LABEL	6A4

he number of labels (3 labels/card) must agree with the number of labels specified in column 7-12 in Record Type 1 The position of the label in the list indicates its label number as described in column 11-15 of Record Type 4a.

Polygon, Point, Line Information - Record Type 4a

Columns	Field description	Format
1	Type, 1 = point, 2 = line, 3 = polygon	I1
2-5	Point, polygon, line number	I4
6-10	Number of points in pt., polygon, or line(1)	I5
11-15	Label number	I5
16-20	Label or point location (MAP X coordinate)	I5
21-25	Label or point location (MAP Y coordinate)	I5
26-30	Polygon envelope (Min-X)	I5
31-35	Polygon envelope (Min-Y)	I5
36-40	Polygon envelope (Max-Y)	I5
41-45	Polygon envelope (Max-Y)	I5
46-51	Polygon area in 0.01 in^2 units	I6

(1) Must agree with the number of points on the following Record Type 4b cards.

Polygon or Line Cards - Record Type 4b

Columns	Field description	Format
1-4	X-Y Map coordinate pair	2I4
9-16	X-Y coordinate pair	2I4
17-24	X-Y coordinate pair	2I4
etc.		
.		
.		
.		
.		
73-80		

There is a maximum of 10 points per card, each with an x and y value or a maximum of 20 records per card. All references to map coordinates are in 0.01 inch units.

B.5 RID*GRID Magnetic Tape Formats

This section contains format information for the output tapes produced by the RID*POLY PGRID routine. For more information reference the RID*GRID User's Manual.

B.5.1 D,E, and F Tape Format

The RID*GRID D,E, and F input records are written onto logical unit 11, which is assigned to a magnetic tape. The records are 80 bytes long and blocked in groups of 80, DCB = (RECFM = FB,LRECL = 80,BLKSIZE = 8000). This file consists of one ''D'' card, one ''E'' card and a variable number of ''F'' cards. See appendix F.6 for a sample listing of this file.

B.5.2 Label Tape Format

The labels corresponding to the polygons output onto logical unit 11 are written to logical unit 13. The length of each record is 80 bytes, however, only the first 36 bytes are used for label information. The labels on this file correspond to the list produced on PGRID printout. An example of a label file is given in appendix F.6.

The DCB information for this file is: RECFM = FB, LRECL = 80, BLKSIZE = 8000.

APPENDIX C. METRIC CONVERSION

The RID*POLY system is currently based on the English system of measurement. To convert RID*POLY to the metric system, the changes listed in table C.1 must be made.

In the English version, map control points (section 3.1) and label coordinates (section 3.2) are recorded in hundredths of inches. Thus, map linear units of 1 inch are represented by "100" on input to POLLY (SCL = 0.01). For the metric version, map control points and label coordinates should be recorded in millimeters. Thus, map linear units of 1 centimeter would be represented on input to POLLY by "10" (SCL = 0.1).

Table C.1 Source code changes required for metric conversion

WRIS program	Control section	English system	Metric system
POLLY	BLOCK DATA NABOR	DATA SCL,HT/.01,.07/ DATA SCL,TH/.01,.07/	DATA SCL,HT/.1, 07/ DATA SCL,TH/.1,.07/
CHART	BLOCK DATA	SCL,HT/.01,.07/	SCL,HT/.1,.07/
	SELFIX	FEET = RF/12. ACRE = FEET**2/43560.	FEET = RF/39.37008 ACRE = FEET**2/10000
	PRNACR	ACRE = RF**2/67272640. FEET = RF/12. .2X,'ITEM',7X,'LOCATION',5X,'(FEET)',4X,'(ACRES)',3X,'LABEL'/)	ACRE = RF**2/(1000.*39.37008**2) FEET = RF/39.37008 .2X,'ITEM',7X,'LOCATION',5X,'(CM.)',4X,'(HECT.)',3X,'LABEL'/
	ITMTOT	FACT = RF**2/6272640. CALL PRNFLO(AR,4,20,'TOTAL AREA (SQ.IN.)') CALL PRNFLO(ACRES,0,18,'TOTAL AREA (ACRES') CALL PRNFLO(DIST,2,26,'TOTAL LINE LENGTH (INCHES)')	FACT = RF**2/(10000.*39.37008**2) CALL PRNFLO(AR,4,20,'TOTAL AREA (SQ.CM)') CALL PRNFLO(ACRES,0,18,'TOTAL AREA (HECTARES)') CALL PRNFLO(DIST,2,26,'TOTAL LINE LENGTH (CENTIMETERS)')
MOSAIC	BLOCK DATA	DATA SCL,HT/.01,.07/	DATA SCL,HT/.1,.07/
	SELFIX	Same as CHART	Same as CHART
	ITMTOT	Same as CHART	Same as CHART
	FRAME	ACRE = F**2/6272640.	ACRE = F**2/(10000*39.37008**2)
	MAIN	*YGONS COMPRISING $I ACRES THAT ARE TOO SMALL TO INCLUDE@', *R POLYGONS COMPRISING $I ACRES@',NULLPO,NULLAC) * 2X,'ACRES',2X,'LABEL',32X,'ITEM',2X,'MINX',2X,'MINY',2X,'MAXX', * 2X,'MAXY',2X,'ACRES',2X,'ACRES')	*YGONS COMPRISING $I HECTARES THAT ARE TOO SMALL TO INCLUDE@', *R POLYGONS COMPRISING $I HECTARES@',NULLPO,NULLAC) * 2X,'HECT.',2X,'LABEL',32X,'ITEM',2X,'MINX',2X,'MINY',2X,'MAXX', * 2X,'MAXY',2X,'HECT.',2X,'HECT.')
	TABLET	CALL PRNTAB(TAB,NLP,NLP,NLQ,LBLP,LBLQ,ACRE,TS,AREA,8,'ACREAGES')	CALL PRNTAB(TAB,NLP,NLP,NLQ,LBLP,LBLQ,ACRE,TS,AREA,7,'HECTARES')

APPENDIX D. DISTRIBUTION NOTES FOR THE IBM VERSION OF RID*POLY

The enclosed tape contains the IBM 360-370 version of RID*POLY. Included on this tape are: FORTRAN and assembly source code, test data, and executable load modules for all RID*POLY programs.

The RID*POLY load modules may be loaded directly onto an IBM 360-370 system, thus eliminating the source code compilation procedures. The load modules were produced on an IBM 360/65 (OS/MVT) and can be executed on any IBM 360-370 system that is upwardly compatible from the 360/65. (The load modules have been loaded and executed on an IBM 370/145 (OS/VS1) without modifications.) At our installation, plotter output is spooled to a disk pack and plotted online. Other installations may spool the plotter output to a tape and plot offline. This difference may require the plotter tape to be initialized in the chart source code.

The RID*POLY programs require a direct access disk file on which to perform intermediate data processing. This file, GINDX.Y1978.WRISDRUM, requires 300 tracks of space on model 3330 disk pack. (The data set name prefix "GINDX.Y1978" is a convention used at our installation for accounting purposes and may vary at other in-stallations.) Installations which have accounting procedures that are Input/Output dependent should create this file in he first BIPRIN run and save it for subsequent runs. Installations with accounting procedures that are not I/O dependent may treat this file as a temporary data set for each job.

The RID*POLY programs use assembly routines TREAD and TWRITE to read and write data on standard-label tapes. The routines can process any file on a given tape with only one DD (data definition) card (//TAPEIN DD or input and //TAPEOUT DD for output). There is one restriction, however; all data set names must be DSN = WRIS.MAPS.

All RID*POLY programs have a data definition card (//FT04F001 DD DUMMY) for logical unit four, which has een assigned to a dummy unit. The original UNIVAC 1108 version of WRIS used this unit for record keeping uring the development phase. This feature was retained in the IBM version for future expansion of the system. Until is feature is used, unit four should be assigned to a dummy unit.

In files 20 thru 28 on the distribution tape, TAPEOUT has been assigned to dummy units. These units should be signed to valid tape files at your installation so that they may be used in subsequent runs. All files necessary for sting purposes have been supplied on the distribution tape. All test files except the initial BIPRIN input file should created and used by the RID*POLY programs at your installation as a further test of the complete sequence of mponents.

The distribution tape is a 9-track 1600 BPI standard-label tape. The volume serial number is WRIS01 OL = SER = WRIS01). The following paragraphs briefly describe the data contained on each file.

le #1
N: WRIS.MAPS
B: RECFM = VBS,LRECL = 6000,BLKSIZE = 6004
SCRIPTION: Scandig scanner binary map-file. Test input for BIPRIN program.

e #2
N: WRIS.MAPS
B: RECFM = FB,LRECL = 80,BLKSIZE = 800
SCRIPTION: Digitizer map file for testing HANDY.

F #3
DN: WRIS.MAPS
DB: RECFM = VBS, LRECL = 6004,BLKSIZE = 6008
DSCRIPTION: Binary map-file produced by BIPRIN which can be used as input to POLLY.

F #4
DN: WRIS.MAPS
DB: RECFM = FB,LRECL = 6000,BLKSIZE = 6000
DSCRIPTION: Polygon map-file produced by the POLLY program which can vbe used as input to MOSAIC, MRGE, TONIC, or XCHG.

File #5

DSN: WRIS.MAPS

DCB: RECFM = VBS,LRECL = 6004,BLKSIZE = 6008

DESCRIPTION: Polygon map-file produced by POLLY which can be used as input to MOSAIC, MERGE, TONIC, or XCHG.

File #6

DSN: WRIS.MAPS

DCB: RECFM = FB,LRECL = 6000,BLKSIZE = 6000

DESCRIPTION: Dummy file to signal end of tape for RID*POLY programs.

Files 7 thru 18 contain the source code for the RID*POLY programs. They all have: DCB = (RECFM = FB, LRECL = 80,BLKSIZE = 12960).

File #	DSN
7	WRIS.ASSEMBLY.SOURCE
8	WRIS.COMMON.SOURCE
9	WRIS.FUNCTION.SOURCE
10	WRIS.HANDY.SOURCE
11	WRIS.BIPRIN.SOURCE
12	WRIS.POLLY.SOURCE
13	WRIS.CHART.SOURCE
14	WRIS.MOSAIC.SOURCE
15	WRIS.MERGE.SOURCE
16	WRIS.TONIC.SOURCE
17	WRIS.XCHG.SOURCE
18	WRIS.PGRID.SOURCE

File #19

DSN: GINDX.Y1978.WRIS.SPLANE

DCB: RECFM = FB,LRECL = 80,BLKSIZE = 800

DESCRIPTION: State plane coordinate transformations for POLLY and MOSAIC.

Files 20 thru 28 contain test data for the WRIS programs. They all have: DCB = (RECFM = FB,LRECL = 80, BLKSIZE = 800)

File #	DSN
20	WRIS.BIPRIN.TEST
21	WRIS.HANDY.TEST
22	WRIS.POLLY.TEST
23	WRIS.CHART.TEST
24	WRIS.MOSAIC.TEST
25	WRIS.MERGE.TEST
26	WRIS.TONIC.TEST
27	WRIS.XCHG.TEST
28	WRIS.PGRID.TEST

File #29
DSN: GINDX.Y1978.WRIS.LOADLIB
DCB: RECFM = FB,LRECL = 80,BLKSIZE = 800
DESCRIPTION: This file contains the GINDX.Y1978.WRIS.LOADLIB partitioned data set, which consists of the object modules for ASSEMBLY, COMMON, and FUNCTION and the load modules for BIPRIN, POLLY, CHART, MERGE, TONIC, XCHG, and MOSAIC. The IBM utility IEHMOVE was used to unload this PDS onto the distributon tape. File 30 contains the JCL needed to load this file onto disk using the IEHMOVE utility. This PDS requires 350 tracks of space on a 3330 disk pack.

File #30
DSN: DSN = WRIS.IEHMOVE
DCB: RECFM = FB,LRECL = 80,BLKSIZE = 800
DESCRIPTION: This file contains the JCL for the IBM utility IEHMOVE, which will load the PDS GINDX.Y1978.WRIS.LOADLIB (file 29) onto disk.

File #31
DSN: WRIS.PROC. DCB: RECFM = FB,LRECL = 80,BLKSIZE = 800
ESCRIPTION: This file contains the JCL procedure required to execute the RID*POLY programs. See appendix for listing.

ile #32
SN: XWRIS.ROUTINES
CB: RECFM = FB,LRECL = 125,BLKSIZE = 13000
ESCRIPTION: This file contains the RID*POLY RUNSTREAM GENERATOR routines. They are written in YLBUR EXEC language.

The following steps should be followed to produce a load module for the RID*POLY system:

ep 1: Compile the assembly routines contained in File #7 and store object module as member ASSEMBLY in a PDS.
ep 2: Compile the FORTRAN IV subroutines common to all programs contained in File #8 and store the resultant object module as member COMMON in the PDS created in Step 1.
ep 3: Compile the FORTRAN IV function routines contained on File #9 and save the object module as member FUNCTION in the Step 1 PDS.
ep 4: Compile the source code contained in File #10, link in the object modules produced in Steps 1 through 3, and store the resultant load module as member HANDY in the Step 1 PDS.
p 5: Repeat Step 4 for files 11 through 18 and store each under the appropriate name.

The above steps will produce a RID*POLY load module library that is ready to execute. Each file on the distribu- tape contains the JCL required to execute a specific task. The JCL was designed to execute at Washington State iversity Computing Center and may require minor modifications to execute at other installations.

Table D.1—Distribution tape contents

VOLUME = WRIS01
1600 BPI, 9-TRACK, IBM STANDARD LABEL

LABEL	DATASET NAME	BLOCK COUNT	RECFM	LRECL	BLKSIZE
1	WRIS.MAPS	25	VBS	6000	6004
2	WRIS.MAPS	3	FB	80	800
3	WRIS.MAPS	25	VBS	6004	6008
4	WRIS.MAPS	6	FB	6000	6000
5	WRIS.MAPS	3	VBS	6004	6008
6	WRIS.MAPS	0	FB	6000	6000
7	WRIS.ASSEMBLY.SOURCE	12	FB	80	12960
8	WRIS.COMMON.SOURCE	30	FB	80	12960
9	WRIS.FUNCTION.SOURCE	3	FB	80	12960
10	WRIS.HANDY.SOURCE	8	FB	80	12960
11	WRIS.BIPRIN.SOURCE	7	FB	80	12960
12	WRIS.POLLY.SOURCE	20	FB	80	12960
13	WRIS.CHART.SOURCE	14	FB	80	12960
14	WRIS.MOSAIC.SOURCE	29	FB	80	12960
15	WRIS.MERGE.SOURCE	9	FB	80	12960
16	WRIS.TONIC.SOURCE	15	FB	80	12960
17	WRIS.XCHG.SOURCE	8	FB	80	12960
18	WRIS.PGRID.SOURCE	10	FB	80	12960
19	GINDX.Y1978.WRIS.SPLANE	12	FB	80	800
20	WRIS.BIPRIN.TEST	1	FB	80	80
21	WRIS.HANDY.TEST	1	FB	80	80
22	WRIS.POLLY.TEST	5	FB	80	80
23	WRIS.CHART.TEST	1	FB	80	80
24	WRIS.MOSAIC.TEST	2	FB	80	80
25	WRIS.MERGE.TEST	1	FB	80	80
26	WRIS.TONIC.TEST	2	FB	80	80
27	WRIS.XCHG.TEST	2	FB	80	80
28	WRIS.PGRID.TEST	2	FB	80	80
29	GINDX.Y1978.WRIS.LOADLIB	4111	FB	80	80
30	WRIS.IEHMOVE	2	FB	80	80
31	WRIS.PROC	3	FB	80	80
32	XWRIS.ROUTINES	12	FB	125	1300

APPENDIX E. RID*POLY RUNSTREAM GENERATOR

The RID*POLY runstream generator is a collection of interactive routines that generate job streams for the RID*POLY programs and perform the necessary file maintenance. Although the routines were developed to operate on the WYLBUR conversational text editing and RJE/RJO system, they could be implemented on any computer installation that supports interactive computing or conversational text editing.

The runstream generator consists of two types of routines, RID*POLY routines and system routines. The RID*POLY routines set up job streams for the various RID*POLY programs, for example, MOSAIC, POLLY, BIPRIN, etc. The system routines set up job streams for the file management system programs, for instance, moving a map-file from one tape to another and deleting a map-file.

The runstream generator routines require access to a map-file data base and a transaction file. The map-file data base is used to maintain a record of all RID*POLY map-files. A map-file is a tape data set that contains map information in either density, binary, or polygon format. The locations (tape reel number and file number) of all map-files used for input are retrieved from this data base. The locations of all output map-files are entered into this data base.

The map-file data base contains temporary and permanent map-files. A temporary map-file is any file produced by RID*POLY program. Temporary map-files are written onto tapes that reside in a scratch pool. When a temporary map-file becomes final, the system routine MOVE is used to copy it onto a tape residing in the permanent tape pool, thus it becomes a permanent map-file.

The transaction file is used to record all transactions that transpire during a session.

When a user signs on the system, control is given to the master routine (#XWRIS). This routine loads the map-file data base and the transaction file onto primary storage (high-speed direct access device). The user is then queried for the name of a program to be run, for example, MOSAIC, POLLY, MOVE, DELETE, etc. Once a program has been selected, its corresponding routine is loaded and control is passed to it. The selected routine queries the user for information required to set up a runstream. It accesses the map-file data base for Input/Output information and records the activity in the transaction file. Upon completion, the generated runstream is sent to the batch processor. If the user rishes to generate another runstream using the routine that is loaded, control is passed to the beginning of the routine. Otherwise, control is returned to the master routine. At this point the user can either select another program or exit. Upon exit, the master routine copies the map-file data base and the transaction file onto secondary storage and he session is terminated.

The following material is a sample session in which runstreams are generated and submitted for both WRIS and ystem programs.

```
EXECUTE # WRIS

WRIS RUNSTREAM GENERATOR
------------------------

TIME - 16:13:15; DATE - 05/07/80

ENTER ACCOUNT FOR THIS SESSION:
[redacted]
ENTER THE USER/GROUP INITIALS OF THE DATASETS YOU WISH TO ACCESS
(E.G., 'DANIM'): DANIM
ENTER FOREST YOU WANT TO WORK WITH: ST. JOE

                    WRIS CONTROL PROGRAM.

ENTER PROGRAM TO EXECUTE (CR TO EXIT; -1 FOR INFO): -1

PROGRAM      DESCRIPTION
-------      -----------
ALLOCATE     ALLOCATES A TAPE FROM THE WSU TAPE POOL.
BIPRIN       BIPRIN RUNSTREAM GENERATOR.
CHART        CHART RUNSTREAM GENERATOR.
DECBACK      BACKS UP EITHER POLLY OR BIPRIN DECKS TO TAPE.
DECKRES      RESTORES EITHER POLLY OR BIPRIN DECKS.
DELETE       DELETES A MAP-FILE FROM A TEMPORARY TAPE.
EDIT         EDITS A BIPRIN OR POLLY FILE.
HANDY        HANDY RUNSTREAM GENERATOR.
MERGE        MERGES TWO POLYGON MAP-FILES.
MOSAIC       MOSAIC RUNSTREAM GENERATOR.
MOVE         MOVES A MAP-FILE FROM A TEMPORARY TO A PERMANENT TAPE.
PGRID        WRIS TO GRID DATA CONVERTER.
POLLY        POLLY RUNSTREAM GENERATOR.
RELEASE      RELEASES A TAPE BACK TO THE WSU TAPE POOL.
TONIC        TONIC RUNSTREAM GENERATOR.
XCHG         XCHG RUNSTREAM GENERATOR.

ENTER PROGRAM TO EXECUTE (CR TO EXIT; -1 FOR INFO): BIPRIN

* * * * *  BIPRIN RUNSTREAM GENERATOR  * * * * *

LAYER: HABITAT
LOCATION: TENSED

 TAPE  WRIS01
LAB M FOREST     MAP# LAYER                LOCATION        DATE
--- - ------     ---- -----                --------        ----
3   1 ST.JOE       59 HABITAT              TENSED          03/23/80
IS THIS THE MAP-FILE YOU WANT? NO

"HABITAT, TENSED" COULD NOT BE FOUND IN THE "STJOELOG" FILE.
DO YOU WISH TO TRY ANOTHER? OK
LAYER: TENSED HAB.
LOCATION: TENSED
```

```
-TAPE- WRIS01
LAB M FOREST      MAP# LAYER                    LOCATION          DATE
--- - --------    ---- -----                    --------          ----
1    1 ST.JOE      2017 TENSED HAB.              TENSED            04/23/80
IS THIS THE MAP-FILE YOU WANT? YES

DO YOU WANT TO UPDATE THE HEADER RECORD? OK
ENTER THE FOLLOWING INFORMATION AS YOU WOULD LIKE IT TO APPEAR IN
THE OUTPUT MAP-FILE.
FOREST (MAX 10 CHARS): ST.JOE
LAYER (MAX 24 CHARS.): HABITAT
LOCATION (MAX 16 CHARS.): TENSED
MAP NUMBER: 59

* * * YOUR MAP-FILE WILL BE WRITTEN TO *WRIS12, LABEL 1.

OPTIONS SECTION:
----------------
DO YOU WANT TO PRINT CORNERS, ALL, NONE, OR WINDOW? CORNERS
DO YOU WANT TO THIN THE BINARY MAP? YES
NUMBER OF PASSES FOR THINNING: 3
DO YOU WANT TO FLIP THE BINARY MAP? NO

ENTER MEMBER IN "BIPRNDKS" WHERE CORRECTIONS ARE (CR-NONE):
DO YOU WANT TO ENTER ANY CORRECTIONS? NO
DO YOU WANT A LIST OF THE RUNSTREAM? OK

       BIPRIN RUNSTREAM

/ WRISRUN JOB (,,50),BIPRIN,MSGLEVEL=(1,1),TIME=5
//PROCLIB DD DSN=GINUX.Y1978.USFS.PROCLIB,DISP=SHR
// EXEC WRIS,PROG=BIPRIN,FILENUM=1
/INPUT DD *
TLES: INPUT=WRIS01; OUTPUT=WRIS12$
EADER: FOREST=ST.JOE;LAYER=TENSED HAB.;MAP=2017$
EADER UPDATES: FOREST=ST.JOE; LAYER=HABITAT; MAP=59;
OCATION=TENSED$
PTIONS: NUMBER OF MAPS=1; PRINT=CORNERS; THIN; ITERATIONS=3$

K TO RUN? OK
RIORITY: DELAY
OB -- 4338 WRISRUN  SENT TO JES2.
O YOU WANT TO RUN ANOTHER "BIPRIN" JOB? NO

                    WRIS CONTROL PROGRAM.

NTER PROGRAM TO EXECUTE (CR TO EXIT; -1 FOR INFO): CHART

* * * *  CHART RUNSTREAM GENERATOR  * * * * *

ODE - 2)POLLY OR 3)MOSAIC: 2
YER: LAND USE
CATION: TENSED
```

```
-TAPE- WRIS01
LAB M FOREST       MAP# LAYER                    LOCATION          DATE
--- - ------       ---- -----                    --------          ----
5   2 ST.JOE        113 LAND USE                 TENSED            04/23/80
IS THIS THE MAP-FILE YOU WANT? YES
DO YOU WANT A PLOT? OK
DO YOU WANT TO SPECIFY ANY PLOT OPTIONS? OK

OPTIONS: 1) MAGNIFICATION FACTOR
         2) PLOT CONTROL POINTS
         3) POLYGON LABELING
         4) PLOT PERIMETER POLYGON

ENTER PLOT OPTION NUMBER (CR - EXIT): 1
ENTER MAGNIFICATION FACTOR: .85

ENTER PLOT OPTION NUMBER (CR - EXIT):
DO YOU WISH TO SELECT A SUBSET OF POLYGONS? NO
DO YOU WANT A MYLAR PLOT? NO
DO YOU WANT A LIST OF THE RUNSTREAM? YES

       CHART RUNSTREAM

//WRISRUN JOB (,,9999),CHART,MSGLEVEL=(1,1),TIME=5
//PROCLIB DD DSN=G1RDX.Y1978.USFS.PROCLIB,DISP=SHR
// EXEC WRIS,PROG=CHART
//PLOTTERC DD SYSOUT=(Q,PLOTWTR,WTP),DEST=LOCAL
//INPUT DD *
FILES: INPUT WRIS01$
HEADER: FOREST=ST.JOE; MAP=113; LAYER=LAND USE$
HEADER UPDATES: FOREST=ST.JOE; MAP=113; LAYER=LAND USE;
LOCATION=TENSED$
OPTIONS: SKIPS=4$
PLOT OPTIONS:  MAGNIFICATION=.85$

OK TO RUN? OK
PRIORITY: DELAY
JOB -- 3347 WRISRUN  SENT TO JES2.
DO YOU WANT TO RUN ANOTHER "CHART" JOB? NO

                    WRIS CONTROL PROGRAM.

ENTER PROGRAM TO EXECUTE (CR TO EXIT; -1 FOR INFO): HANDY

* * * * *  HANDY RUNSTREAM GENERATOR  * * * * *

LAYER: LAND USE
LOCATION: BUZZARD

 TAPE - WRIS01
LAB M FOREST       MAP# LAYER                    LOCATION          DATE
--- - ------       ---- -----                    --------          ----
2   5 ST.JOE        100 LAND USE                 BUZZARD ROOST     04/23/80
IS THIS THE MAP-FILE YOU WANT? YES
```

```
DO YOU WANT TO UPDATE THE HEADER RECORD? NO

* * * YOUR MAP-FILE WILL BE WRITTEN TO *WRIS13, LABEL 1.

DO YOU WANT A LIST OF THE RUNSTREAM? YES

       HANDY RUNSTREAM

//WRISRUN JOB (,,35),HANDY,MSGLEVEL=(1,1),TIME=5
//PROCLIB DD DSN=GINDX.Y1978.USFS.PROCLIB,DISP=SHR
// EXEC WRIS,PROG=HANDY,FILENUM=1
//INPUT DD *
FILES: INPUT=WRIS01; OUTPUT=WRIS13$
HEADER: FOREST=ST.JOE; LAYER=LAND USE; MAP 100;
LOCATION=BUZZARD ROOST$
OPTIONS: SKIPS=1$

OK TO RUN? OK
PRIORITY: DELAY
JOB -- 4362 WRISRUN  SENT TO JES2.
DO YOU WANT TO RUN ANOTHER "HANDY" JOB? NO

                    WRIS CONTROL PROGRAM.

NTER PROGRAM TO EXECUTE (CR TO EXIT; -1 FOR INFO): MERGE

* * * * *  MERGE RUNSTREAM GENERATOR  * * * * *

ARNING - - - TO REDUCE PROCESSING COSTS, ALWAYS ENTER THE
LARGEST MAP-FILE FIRST.

ODE - 2)POLLY OR 3)MOSAIC: 2

NTER FILE INFORMATION FOR FIRST MAP-FILE.
AYER: HABITAT
OCATION: TENSED

TAPE- WRIS01
AB M FOREST      MAP# LAYER                      LOCATION         DATE
-- - ------      ---- -----                      --------         -
   2 ST.JOE        59 HABITAT                    TENSED           01/23/80
S THIS THE MAP-FILE YOU WANT? YES
O YOU WANT TO ENTER ANY SELECTION CRITERIA FOR MAP-FILE ONE? NO

NTER FILE INFORMATION FOR SECOND MAP-FILE.
YER: LAND USE
CATION: TENSED

APE-*WRIS14(  1) - MERGE
LB M FOREST      MAP# LAYER                      LOCATION         DATE
-- - ------      ---- -----                      --------         -
1  2 ST.JOE      113  LAND USE                   TENSED           05/02/80
I THIS THE MAP-FILE YOU WANT? NO
```

```
-TAPE- WRIS01
LAB M FOREST      MAP# LAYER                         LOCATION        DATE
--- - ------      ---- -----                         --------        ----
5   2 ST.JOE       113 LAND USE                      TENSED          04/23/80
IS THIS THE MAP-FILE YOU WANT? YES
DO YOU WANT TO ENTER ANY SELECTION CRITERIA FOR MAP-FILE TWO? NO
DO YOU WANT TO WRITE OUTPUT FILE ONTO TAPE? NO
DO YOU WANT A LIST OF THE RUNSTREAM? OK

       MERGE RUNSTREAM

//WRISRUN JOB (,,50),MERGE,MSGLEVEL=(1,1),TIME=5
//PROCLIB DD DSN=GINDC.Y1978.USFS.PROCLIB,DISP=SHR
// EXEC WRIS,PROG=MERGE,FILENUM=1
//INPUT DD *
FILES: INPUT ONE=WRIS01; INPUT TWO=WRIS01; OUTPUT=NONE$
HEADER ONE: FOREST=ST.JOE; MAP=59; LAYER=HABITAT$
OPTIONS: SKIPS=3$
HEADER TWO: FOREST=ST.JOE; MAP=113; LAYER=LAND USE$
OPTIONS: SKIPS=4$
OUTPUT HEADER: FOREST=ST.JOE; LAYER=LAND USE; MAP=113$

OK TO RUN? OK
PRIORITY: DELAY
JOB --- 4399 WRISRUN  SENT TO JES2.
DO YOU WANT TO RUN ANOTHER "MERGE" JOB? NO

                    WRIS CONTROL PROGRAM.

ENTER PROGRAM TO EXECUTE (CR TO EXIT; -1 FOR INFO): MOSAIC

* * * * *  MOSAIC RUNSTREAM GENERATOR  * * * * *

ENTER FILE INFORMATION FOR FIRST MAP-FILE.
ENTER MODE 2)POLLY OR 3)MOSAIC: 2
LAYER: HABITAT
LOCATION: TENSED

-TAPE- WRIS01
LAB M FOREST      MAP# LAYER                         LOCATION        DATE
--- - ------      ---- -----                         --------        ----
4   2 ST.JOE        59 HABITAT                       TENSED          04/23/80
IS THIS THE MAP-FILE YOU WANT? YES
ENTER THINNING FACTOR(CR-DEFAULT TO 2.0):
DO YOU WANT TO ENTER ANY SELECTION CRITERIA FOR MAP-FILE ONE? NO

ENTER FILE INFORMATION FOR SECOND MAP-FILE.
ENTER MODE 2)POLLY OR 3)MOSAIC: 2
LAYER: LAND USE
LOCATION: TENSED
```

```
-TAPE-*WRIS14(   1) - MERGE
LAB M FOREST      MAP# LAYER                          LOCATION          DATE
--- - ------      ---- -----                          -------- ----     ----
1   2 ST.JOE      113  LAND USE                       TENSED            05/07/80
IS THIS THE MAP-FILE YOU WANT? NO

-TAPE- WRIS01
LAB M FOREST      MAP# LAYER                          LOCATION          DATE
--- - ------      ---- -----                          -------- ----     ----
5   2 ST.JOE       113 LAND USE                       TENSED            04/23/80
IS THIS THE MAP-FILE YOU WANT? OK
ENTER THINNING FACTOR(CR-DEFAULT TO 2.0):
DO YOU WANT TO ENTER ANY SELECTION CRITERIA FOR MAP-FILE TWO? YES

POLYGON SELECTIONS SECTION.

ENTER OPTION NUMBER (CR - EXIT, -1 OPTION LISTING): -1

OPTIONS: 1) INCLUDE ITEMS=LIST OF ITEM NUMBERS;
         2) EXCLUDE ITEMS=LIST OF ITEM NUMBERS;
         3) INCLUDE TYPES=LIST OF TYPE NUMBERS;
         4) EXCLUDE TYPES=LIST OF TYPE NUMBERS;
         5) INCLUDE LABELS=LABEL LIST;
         6) EXCLUDE LABELS=LABEL LIST;
         7) INCLUDE AREAS GREATER THAN=X;
         8) EXCLUDE AREAS GREATER THAN=X;
         9) INCLUDE PERIMETERS GREATER THAN=X;
        10) EXCLUDE PERIMETERS GREATER THAN=X;
        11) INCLUDE RECTANGLE=MIN X,MAX X,MIN Y,MAX Y;

NTER OPTION NUMBER (CR - EXIT, -1 OPTION LISTING): 7
NCLUDE AREAS GREATER THAN (IN ACRES): 5.0?

NTER OPTION NUMBER (CR - EXIT, -1 OPTION LISTING):

OLYGON SELECTION COMPLETED.
O YOU WANT TO WRITE OUTPUT FILE ONTO TAPE? NO
O YOU WANT TO SPECIFY ANY MOSAIC OPTIONS? OK

PTIONS: 1) MINIMUM INPUT POLYGON AREA=X (5.0 ACRES DEFAULT);
        2) MINIMUM OUTPUT POLYGON AREA=X (5.0 ACRES DEFAULT);
        3) MINIMUM MAP SLIVER WIDTH=X1;
        4) MINIMUM GROUND SLIVER WIDTH=X2

NTER MOSAIC OPTION NUMBER (CR - EXIT): 1
NTER MINIMUM INPUT POLYGON AREA (IN ACRES): 2.0

NTER MOSAIC OPTION NUMBER (CR - EXIT): 2
NTER MINIMUM OUTPUT POLYGON AREA (IN ACRES): 1.0

NTER MOSAIC OPTION NUMBER (CR - EXIT): 4
NTER MINIMUM GROUND SLIVER WIDTH (IN FEET): 150.0

NTER MOSAIC OPTION NUMBER (CR - EXIT):
```

```
DO YOU WANT A LIST OF THE RUNSTREAM? OK

       MOSAIC RUNSTREAM

//WRISRUN JOB (,,50),MOSAIC,MSGLEVEL=(1,1),TIME=5
//PROCLIB DD DSN=GINDX.Y1978.USFS.PROCLIB,DISP=SHR
// EXEC WRIS,PROG=MOSAIC,FILENUM=1
  INPUT DD *
FILES: INPUT ONE=WRIS01; INPUT TWO=WRIS01; OUTPUT=NONE$
HEADER ONE: FOREST=ST.JOE; MAP=59; LAYER=HABITAT;
STATE=IDAHO; ZONE=3$
OPTIONS: SKIPS=3$
HEADER TWO: FOREST=ST.JOE; MAP=113; LAYER=LAND USE;
STATE=IDAHO; ZONE=3$
OPTIONS: SKIPS=4$
POLYGON SELECTIONS:
INCLUDE AREAS GREATER THAN=5.09$
OUTPUT HEADER: FOREST=ST.JOE; LAYER=HABITAT/LAND USE; MAP=113;
LOCATION=TENSED;
STATE=IDAHO; ZONE=3$
MOSAIC OPTIONS: MINIMUM INPUT POLYGON AREA=2.0;
                MINIMUM OUTPUT POLYGON AREA=1.0;
                MINIMUM GROUND SLIVER WIDTH=150.0$

OK TO RUN? OK
PRIORITY: DELAY
JOB -- 4451 WRISRUN  SENT TO JES2.
DO YOU WANT TO RUN ANOTHER "MOSAIC" JOB? NO

                    WRIS CONTROL PROGRAM.

ENTER PROGRAM TO EXECUTE (CR TO EXIT; -1 FOR INFO): PGRID

* * * * *  PGRID RUNSTREAM GENERATOR  * * * * *

ENTER MODE - 2)POLLY OR 3)MOSAIC: 2
LAYER: HABITAT
LOCATION: TENSED

-TAPE- WRIS01
LAB M FOREST      MAP# LAYER                      LOCATION          DATE
--- - ---------   ---- ------                     --------          ----
4   2 ST.JOE        59 HABITAT                    TENSED            04/23/8
IS THIS THE MAP-FILE YOU WANT? YES
DO YOU WISH TO SELECT A SUBSET OF POLYGONS? OK

POLYGON SELECTIONS SECTION.

ENTER OPTION NUMBER (CR - EXIT, -1 OPTION LISTING): 1
ENTER "ITEMS TO BE INCLUDED" (A SEMICOLON FOLLOWING THE
LAST VALUE WILL TERMINATE THIS OPTION).
ENTER VALUES: 2;8;
```

```
POLYGON SELECTION COMPLETED.
DO YOU WANT GRID DATA WRITTEN ON: 1)CARDS OR 2)TAPE? 2
OUTPUT FILE 11 (GRID "D", "E", AND "F" CARDS):
     ENTER TAPE VOL=SER: WRIS22
     FILE ON WRIS22 TO WRITE TO: 1
     DSN FOR THAT FILE: TENSED.HABITAT.DEF.CARDS
OUTPUT FILE 13 (POLYGON LABELS):
     ENTER TAPE VOL=SER: WRIS22
     FILE ON WRIS22 TO WRITE TO: 2
     DSN FOR THAT FILE: TENSED.HABITAT.LABELS
DO YOU WANT A LIST OF THE RUNSTREAM? YES

       FGRID RUNSTREAM

//WRISRUN JOB (,,50,9999),FGRID,MSGLEVEL=(1,1),TIME=5
//PROCLIB DD DSN=GINDX.Y1978.USFS.PROCLIB,DISP=SHR
// EXEC WRIS,PROG=FGRID,
// TPOUT#1=WRIS22,FILE#1=1,NAME#1='TENSED.HABITAT.DEF.CARDS',
// TPOUT#2=WRIS22,FILE#2=2,NAME#2='TENSED.HABITAT.LABELS'
//INPUT DD *
FILES: INPUT=WRIS01$
HEADER: FOREST=ST.JOE; LAYER=HABITAT; MAP=59$
OPTIONS: SKIPS=3$
POLYGON SELECTIONS:
INCLUDE ITEMS=2:8$

OK TO RUN? OK
PRIORITY: DELAY
JOB --- 4472 WRISRUN  SENT TO JES2.
DO YOU WANT TO RUN ANOTHER "FGRID" JOB? NO

                    WRIS CONTROL PROGRAM.

ENTER PROGRAM TO EXECUTE (CR TO EXIT; -I FOR INFO): FOLLY

* * * * *  FOLLY RUNSTREAM GENERATOR  * * * * *

THIS EXEC FILE REQUIRES A MEMBER TO BE STORED IN
GINDX.Y1978.FOLLYDKS.  THIS FILE MUST CONTAIN: 1) CONTROL
POINTS, 2) CORRECTIONS SECTION, AND 3) LABELS SECTION.
(CHANGES CAN BE MADE BY THE #EXEDIT EXEC FILE.)

ARE YOU WORKING WITH (1) BIPRIN DATA OR (2) HANDY DATA? 1
LAYER: HABITAT
LOCATION: TENSED

TAPE-*WRIS12(  1) - BIPRIN
LAB M FOREST      MAP# LAYER                    LOCATION         DATE
--- - ----------  ---- ----------               ----------       --------
L   1 ST.JOE      59   HABITAT                  TENSED           [illegible]
IS THIS THE MAP-FILE YOU WANT? NO
```

```
-TAPE- WRIS01
LAB M FOREST     MAP# LAYER                  LOCATION         DATE
--- - ------     ---- -----                  --------         ----
3   1 ST.JOE       59 HABITAT                TENSED           04/23/80
IS THIS THE MAP-FILE YOU WANT? YES

DO YOU WANT TO UPDATE THE HEADER RECORD? NO

* * * YOUR MAP-FILE WILL BE WRITTEN TO *WRIS15, LABEL 1.

         OPTIONS SECTION.
1) SWAPXY, 2) CHECK HOLES (CR-EXIT):
ENTER MEMBER NAME IN GIDDX.Y1978.POLLYDKS: HTENSED
DO YOU WANT A LIST OF THE RUNSTREAM? NO
OK TO RUN? OK
PRIORITY: DELAY
JOB -- 4495 WRISRUN  SENT TO JES2.
DO YOU WANT TO RUN ANOTHER "POLLY" JOB? NO

                    WRIS CONTROL PROGRAM.

ENTER PROGRAM TO EXECUTE (CR TO EXIT; -1 FOR INFO): TONIC

* * * * *  TONIC RUNSTREAM GENERATOR  * * * * *

MODE - 2)POLLY OR 3)MOSAIC: 2
LAYER: HABITAT
LOCATION: TENSED

-TAPE-*WRIS15(   1)   POLLY
LAB M FOREST     MAP# LAYER                  LOCATION         DATE
--- - ------     ---- -----                  --------         ----
1   2 ST.JOE     59   HABITAT                TENSED           05/07/80
IS THIS THE MAP-FILE YOU WANT? NO

-TAPE- WRIS01
LAB M FOREST     MAP# LAYER                  LOCATION         DATE
--- - ------     ---- -----                  --------         ----
4   2 ST.JOE       59 HABITAT                TENSED           04/23/80
IS THIS THE MAP-FILE YOU WANT? YES
DO YOU WANT TO WRITE ONTO TAPE? NO

ENTER TONIC OPTION NUMBER(CR-EXIT,-1 OPTION LISTING): -1

OPTIONS: 1) HEADER UPDATES
         2) POLYGON SELECTIONS
         3) LABEL COMBINATIONS
         4) NEW LABELS
         5) NEW LABELS BY LOCATION
         6) NEW LABEL LOCATIONS
         7) STORE ACREAGES
```

```
ENTER TONIC OPTION NUMBER(CR-EXIT, -1 OPTION LISTING): 3
ENTER LABEL COMBINATIONS:  (80 CHARACTERS OR LESS PER LINE, A DOLLAR SIGN
FOLLOWING THE LAST VALUE WILL  TERMINATE THIS OPTION).
ENTER VALUES: 500=510,520,530$

ENTER TONIC OPTION NUMBER(CR-EXIT, -1 OPTION LISTING): 4
ENTER NEW LABELS:  (80 CHARACTERS OR LESS PER LINE, A DOLLAR SIGN
FOLLOWING THE LAST VALUE WILL  TERMINATE THIS OPTION).
ENTER VALUES: 2,PVT;3,880$

ENTER TONIC OPTION NUMBER(CR-EXIT,-1 OPTION LISTING): 5
ENTER NEW LABELS BY LOCATION:  (80 CHARACTERS OR LESS PER LINE, A DOLLAR SIGN
FOLLOWING THE LAST VALUE WILL  TERMINATE THIS OPTION).
ENTER VALUES: 999 1487 1417, 998 339 1138$

ENTER TONIC OPTION NUMBER(CR-EXIT,-1 OPTION LISTING): 6
ENTER NEW LABEL LOCATIONS:  (80 CHARACTERS OR LESS PER LINE, A DOLLAR SIGN
FOLLOWING THE LAST VALUE WILL  TERMINATE THIS OPTION).
ENTER VALUES: 4,1480,1410; 11,340,1140$

ENTER TONIC OPTION NUMBER(CR-EXIT,-1 OPTION LISTING):
DO YOU WANT A LIST OF THE RUNSTREAM? OK

       TONIC RUNSTREAM

//WRISRUN JOB (,,45),TONIC,MSGLEVEL=(1,1),TIME=5
//PROCLIB DD DSN=G1NDX.Y1978.USFS.PROCLIB,DISP=SHR
// EXEC WRIS,PROG=TONIC,FILENUM=1
//INPUT DD *
FILES: INPUT=WRIS01; OUTPUT=NONE$
HEADER: FOREST=ST.JOE; MAP=59; LAYER=HABITAT$
OPTIONS: SKIPS=3$
HEADER UPDATES: FOREST=ST.JOE; MAP=59; LAYER=HABITAT;
LOCATION=TENSED$
LABEL COMBINATIONS: 500=510,520,530$
NEW LABELS: 2,PVT;3,880$
NEW LABELS BY LOCATION: 999 1487 1417, 998 339 1138$
NEW LABEL LOCATIONS: 4,1480,1410; 11,340,1140$

OK TO RUN? OK
PRIORITY: DELAY
JOB -- 4515 WRISRUN  SENT TO JES2.
DO YOU WANT TO RUN ANOTHER "TONIC" JOB? NO

                    WRIS CONTROL PROGRAM.

ENTER PROGRAM TO EXECUTE (CR TO EXIT; -1 FOR INFO): XCHG

* * * * *  XCHG RUNSTREAM GENERATOR  * * * * *

ENTER MODE - 2)POLLY OR 3)MOSAIC: 2
LAYER: HABITAT
OCATION: TENSED
```

```
 TAPE $WRIS15(  1) - POLL.
LAB M FOREST      MAP# LAYER                           LOCATION          DATE
--- - ------      ---- -----                           --------          ----
1   2 ST.JOE      59   HABITAT                         TENSED            05/07/80
IS THIS THE MAP-FILE YOU WANT? NO

-TAPE- WRIS01
LAB M FOREST      MAP# LAYER                           LOCATION          DATE
--- - ------      ---- -----                           --------          ----
4   2 ST.JOE        59 HABITAT                         TENSED            04/23/80
IS THIS THE MAP-FILE YOU WANT? YES

OPTIONS: 1) TRIM
         2) NOTRIM
         3) LABELS
         4) NOLABELS

ENTER OPTION NUMBER (CR TO EXIT):
DO YOU WISH TO SELECT A SUBSET OF POLYGONS? YES

POLYGON SELECTIONS SECTION.

ENTER OPTION NUMBER (CR - EXIT, -1 OPTION LISTING): 1
ENTER "ITEMS TO BE INCLUDED" (A SEMICOLON FOLLOWING THE
LAST VALUE WILL TERMINATE THIS OPTION).
ENTER VALUES: 2;8;

POLYGON SELECTION COMPLETED.
DO YOU WANT XCHG DATA WRITTEN ON: 1)CARDS OR 2)TAPE? 1
DO YOU WANT A LIST OF THE RUNSTREAM? OK

        XCHG RUNSTREAM

//WRISRUN JOB (,,55,9999),XCHG,MSGLEVEL=(1,1),TIME=5
//PROCLIB DD DSN=GINDX.Y1978.USFS.PROCLIB,DISP=SHR
// EXEC WRIS,PROG=XCHG
//FT11F001 DD SYSOUT=B
//INPUT DD *
FILES: INPUT=WRIS01$
HEADER: FOREST=ST.JOE; LAYER=HABITAT; MAP=59$
HEADER UPDATES: FOREST=ST.JOE;LAYER=HABITAT;MAP=59;
LOCATION=TENSED$
OPTIONS: SKIPS=3$
POLYGON SELECTIONS:
INCLUDE ITEMS=2;8$

OK TO RUN? OK
PRIORITY: DELAY
JOB -- 4539 WRISRUN  SENT TO JES2.
DO YOU WANT TO RUN ANOTHER "XCHG" JOB? NO
```

```
                         WRIS CONTROL PROGRAM.

ENTER PROGRAM TO EXECUTE (CR TO EXIT; -I FOR INFO):
STJOELOG REPLACED ON USER04
STJOEACT REPLACED ON USER01

END OF #XWRIS SESSION.
```

APPENDIX F. RID*POLY SAMPLE RUNS

The sample runs contained in this appendix were produced from the job streams listed in previous chapters of this manual. The job stream decks are contained on the distribution tape (see appendix D).

F.1 BIPRIN

```
                                                                                     BIPRIN     14 FEB 80  22:18:23    0      1
                                        INPUT CARD' FILES: INPUT=WRIS01; OUTPUT=NONE$


INPUT
   REEL WRIS01


OUTPUT
   'NONE'
                                        INPUT CARD' HEADER: FOREST=ST. JOE;LAYER=TENSED HAB.;MAP=2017$
                                        INPUT CARD' HEADER UPDATES: FOREST=ST.JOE;LAYER=HABITAT;MAP=59;
                                        INPUT CARD' LOCATION=TENSED$
                                        INPUT CARD' OPTIONS: NUMBER OF MAPS=1; PRINT=CORNERS; THIN; ITERATIONS=3$

PREPARING TO READ INPUT FILE FROM  REEL WRIS01

SCANNER SETUP...  SEQUENCE=5  BITS/PIXEL=1  THRESHOLD=95  INCREMENT=2
X LENGTH=64  Y OFFSET=26  Y LENGTH=46
   POSITION 1   ST. JOE  TENSED HAB.  MAP 2017  .309 SECONDS

HEADER RECORD
   FOREST = ST. JOE;   MAP = 2017;   LAYER = TENSED HAB.;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 0

UPDATED HEADER RECORD
   FOREST = ST.JOE;   MAP = 59;   LAYER = HABITAT;   LOCATION = TENSED;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 0

NO ADDITIONS OR DELETIONS
                                                                                                    BIPRIN   2.8734 SEC

THINNING:   6 SECONDS   3 PASSES
                                                                                                    BIPRIN   5.6793 SEC
MAP PIECES TO BE PRINTED:
         ROW    1 TO ROW   60, COLUMN    1 TO COLUMN  120
         ROW 1231 TO ROW 1283, COLUMN    1 TO COLUMN  120
         ROW    1 TO ROW   60, COLUMN  809 TO COLUMN  928
         ROW 1231 TO ROW 1283, COLUMN  809 TO COLUMN  928
                                                                                                    BIPRIN   0.0107 SEC
```

```
                                                           60   65   70   75   80   85   90   95  100  105  110  115  120
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89 51
90 51
BIPRIN 0.1657 SEC

```
    5   10   15   20   25   30   35   40   45   50   55   60   65   70   75   80   85   90   95  100  105  110  115  120
....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'
                                                                                                          BIPRIN   0.0623 SEC
```

```
   813  818  823  828  833  838  843  848  853  858  863  868  873  878  883  888  893  898  903  908  913  918  923  928
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                                                                    1                                                       78 53
```

```
                  79 53
                  80 53
BIPRIN  0.1652 SEC
```

```
    813  818  823  828  833  838  843  848  853  858  863  868  873  878  883  888  893  898  903  908  913  918  923  928
 ....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....'....  BIPRIN   0.0635 SEC

NO OUTPUT FILE
*********************************************** END OF MAP NO.     59 *************************************************************
                                                                                                              BIPRIN   0.0145 SEC

DATE  14 FEB 80      TIME  22:20:54

END OF RUN
```

```
                                                                                          CHART      08 FEB 80  09:21:30    0      1
                                               INPUT CARD' FILES: INPUT=WRIS01$


INPUT
   REEL WRIS01
                                               INPUT CARD' HEADER: FOREST=ST.JOE; MAP=113; LAYER=LAND USE$
                                               INPUT CARD' OPTIONS: SKIPS=3$
                                               INPUT CARD' HEADER UPDATES: FOREST=ST.JOE; MAP=113; LAYER=LAND USE;
                                               INPUT CARD' LOCATION=TENSED$
                                               INPUT CARD' PLOT OPTIONS:  MAGNIFICATION=.85$


MAGNIFICATION    .8499996

PLOT ITEM NUMBERS

PREPARING TO READ INPUT FILE FROM  REEL WRIS01
   POSITION 4   ST.JOE  HABITAT  MAP 59  TENSED   14 AUG 79  20:49:23    8086 WORDS  .067 SECONDS     (SKIPPED)
   POSITION 5   ST.JOE  LAND USE  MAP 113  TENSED   02 MAY 78  23:59:38    3829 WORDS  .100 SECONDS

NUMBER OF POLYGONS: 23   NUMBER OF X-Y POINTS: 3502   AVERAGE NUMBER OF X-Y POINTS PER POLYGON: 152

HEADER RECORD
   FOREST = ST.JOE;   MAP = 113;   LAYER = LAND USE;   LOCATION = TENSED;   SCALE = 31680;
   GEOGRAPHIC CONTROL POINTS = 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 100, 100, 105, 1840, 2460, 1835, 2460, 100;   GRID CONTROL POINTS = 917, 45, 36, 28, 19, 1226, 895, 1243;
   ZONE - 3;   STATE = IDAHO;   SCAN ROWS = 943;   SCAN COLUMNS = 1312;   MODE = 2;   ENVELOPE = 101, 97, 2462, 1840;
   DATE WRITTEN = 02 MAY 78;   TIME WRITTEN = 23:59:38;   RFEL NUMBER = CC6938

LABELS
   1 PERIMETER   4 303
   2 999         5 PVT
   3 500


UPDATED HEADER RECORD
   FOREST - ST.JOE;   MAP = 113;   LAYER = LAND USE;   LOCATION = TENSED;   SCALE = 31680;
   GEOGRAPHIC CONTROL POINTS = 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 100, 100, 105, 1840, 2460, 1835, 2460, 100;   GRID CONTROL POINTS = 917, 45, 36, 28, 19, 1226, 895, 1243;
   ZONE = 3;   STATE = IDAHO;   SCAN ROWS = 943;   SCAN COLUMNS = 1312;   MODE = 2;   ENVELOPE = 101, 97, 2462, 1840;
   DATE WRITTEN = 02 MAY 78;   TIME WRITTEN = 23:59:38;   REEL NUMBER = CC6938

THERE ARE 22 ITEMS TO BE PLOTTED
```

```
ST.JOE  MAP 113  LAND USE                                                                         CHART      08 FEB 80  09:24:14
ITEM TYPE LENGTH       AREA   PTS    FIRST POINT      RANGE OF X,       RANGE OF Y         LABEL LOC   LABEL
   2     3    2.49    0.3099   28    24.61 17.19    24.21 24.62     17.17 18.12      24.50 17.60    500
   3     3    1.06    0.0465   21     3.79 15.48     3.63  3.81     15.20 15.62       3.70 15.50    500
   4     3   14.55    6.8113  331    24.60 14.86    21.03 24.62     12.54 17.61      23.50 15.50    999
   5     3   62.04  151.2955  916    22.45 14.85     1.03 24.61      7.05 18.40      14.00 15.00    999
   6     3    2.06    0.2629   16    24.60 13.93    24.08 24.62     13.71 14.23      24.40 14.00    500
   7     3   14.21    7.6692  208    24.60 12.19    21.24 24.62      9.73 14.19      23.50 12.50    999
   8     3    1.86    0.1875   24    21.23 12.05    20.72 21.25     12.04 12.55      21.00 12.30    500
   9     3   29.79   40.2956  404     7.61 11.89     1.01  7.92      6.56 16.55       4.00 12.00    999
  10     3    4.44    0.7560   20     8.92 11.12     7.05  8.93     11.12 11.61       8.00 11.50    500
  11     3   10.86    4.9833   70    12.67  9.01    10.85 12.69      7.51 11.49      11.50  9.50    303
  12     3   11.74    3.7466   40    24.59  8.86    22.73 24.61      7.70 11.22      24.00  9.00    500
  13     3    6.01    1.9919   18     5.90  8.75     4.89  5.91      7.59  9.62       5.50  9.00    500
  14     3   25.69   12.0451  150    22.68  7.49    16.14 22.73      5.48 10.02      20.00  8.00    500
  15     3    3.68    0.5464   58    18.64  7.50    17.83 18.66      7.49  8.75      18.40  7.70    PVT
  16     3    2.13    0.2953    8    24.60  6.19    24.03 24.61      6.19  6.72      24.50  6.50    500
  17     3   62.42   39.6533  371    24.59  5.94    14.48 24.61      1.00 12.06      22.00  6.00    999
  18     3   56.26  112.3983  480    16.14  5.49     1.01 17.18      0.97 11.41       9.00  6.00    999
  19     3    3.99    0.7279   17    16.13  5.00    14.64 16.14      4.98  5.50      15.50  5.30    500
  20     3    3.96    0.9822   14    14.62  3.50    13.64 14.64      3.48  4.51      14.00  4.00    500
  21     3   26.15   21.0462   75    24.59  2.22    16.72 24.61      1.00  5.52      21.00  3.00    500
  22     3    6.04    1.0945   24    16.20  1.55    14.18 16.21      1.00  2.06      15.50  1.80    500
  23     3    6.17    2.2307   20    24.59  1.03    22.69 24.61      1.01  2.22      23.50  1.50    PVT

NUMBER OF ITEMS (EXCLUDING PERIMETER POLYGON)    22

TOTAL NUMBER OF POINTS    3313

TOTAL AREA (SQ. IN.)    409.3754

TOTAL AREA (ACRES)    65500

TOTAL LINE LENGTH (INCHES)    357.60
```

```
 ST. JOE  MAP 113  LAND USE                                                                CHART      08 FEB 80  09:24:14     1
                             LINE
                LABEL       LENGTH       AREA
  ITEM         LOCATION     (FEET)     (ACRES)    LABEL

     2     24.50 17.60       6562          50     500
     3      3.70 15.50       2807           7     500
     4     23.50 15.50      38422        1090     999
     5     14.00 15.00     163775       24207     999
     6     24.40 14.00       5429          42     500
     7     23.50 12.50      37525        1227     999
     8     21.00 12.30       4903          30     500
     9      4.00 12.00      78652        6447     999
    10      8.00 11.50      11718         121     500
    11     11.50  9.50      28660         797     303
    12     24.00  9.00      30981         599     500
    13      5.50  9.00      15875         319     500
    14     20.00  8.00      67832        1927     500
    15     18.40  7.70       9713          87     PVT
    16     24.50  6.50       5633          47     500
    17     22.00  6.00     164797        6345     999
    18      9.00  6.00     148530       17984     999
    19     15.50  5.30      10530         116     500
    20     14.00  4.00      10461         157     500
    21     21.00  3.00      69036        3367     500
    22     15.50  1.80      15935         175     500
    23     23.50  1.50      16293         357     PVT



AGGREGATE AREAS BY LABEL

999   57300
500    6959
303     797
PVT     444

      65500 TOTAL
```

```
                                                                CHART      08 FEB 80  09:24:14    1       4
PLOTTING IS COMPLETED
DATE  08 FEB 80     TIME  09:24:14
END OF RUN
```

```
                                         INPUT CARD' FILES: INPUT=WRIS01; OUTPUT=NONE$      HANDY      13 MAR 80  23:23:44     0

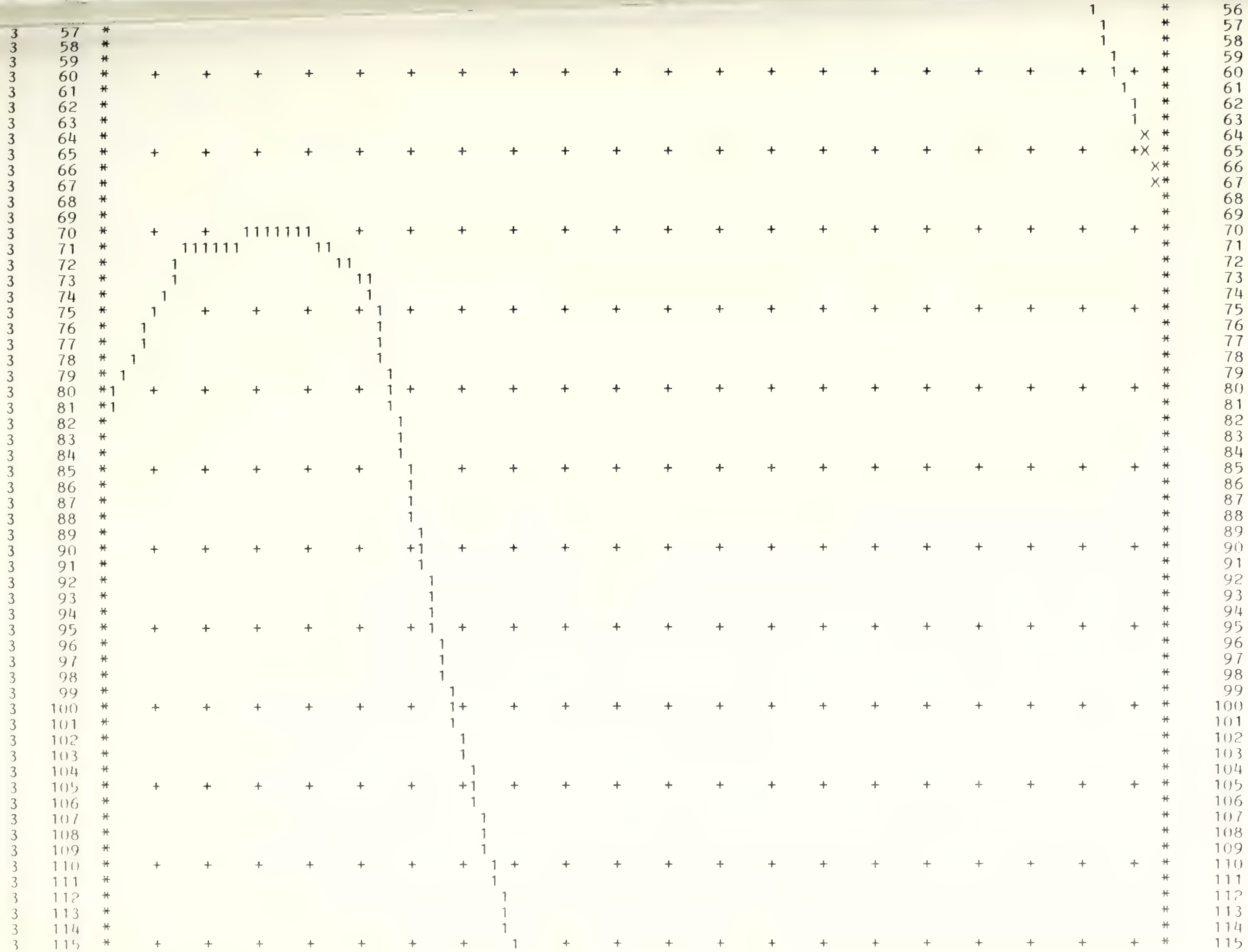
  INPUT
    REEL WRIS01

  OUTPUT
    'NONE'
                                         INPUT CARD' HEADER: FOREST=ST.JOE;LAYER=LAND USE;MAP=100;
                                         INPUT CARD' LOCATION=BUZZARD ROOST$
                                         INPUT CARD' OPTIONS: SKIPS=1$
                                                                                                     HANDY     0.3772 SEC
                                                                                                     HANDY     0.4259 SEC
                                                                                                     HANDY    14.3011 SEC
  THINNING:    6 SECONDS    20 PASSES                                                                HANDY    29.9914 SEC

                                                                                                     HANDY     5.8815 SEC
```

THE FOLLOWING IS A SUBSET OF THE BINARY MAPS PRODUCED BY THE TEST RUN OF "HANDY":

```
              305  310  315  320  325  330  335  340  345  350  355  360  365  370  375  380  385  390  395  400
           *****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|***
3       1  *                                                                                                      *        1
3       2  *1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111XX*        2
3       3  *                                                                                                      *        3
3       4  *                                                                                                      *        4
3       5  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *        5
3       6  *                                                                                                      *        6
3       7  *                                                                                                      *        7
3       8  *                                                                                                      *        8
3       9  *                                                                                                      *        9
3      10  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *       10
3      11  *                                                                                                      *       11
3      12  *                                                                                                      *       12
3      13  *                                                                                                      *       13
3      14  *                                                                                                      *       14
3      15  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *       15
3      16  *                                                                                                      *       16
3      17  *                                                                                                      *       17
3      18  *                                                                                                      *       18
3      19  *                                                                                                      *       19
3      20  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *       20
3      21  *                                                                                                      *       21
3      22  *                                                                                                      *       22
3      23  *                                                                                                      *       23
3      24  *                                                                                                      *       24
3      25  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *       25
3      26  *                                                                                                      *       26
3      27  *                                                                                                      *       27
3      28  *                                                                                                      *       28
3      29  *                                                                                                      *       29
3      30  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *       30
3      31  *                                                                                                      *       31
3      32  *                                                                                                      *       32
3      33  *                                                                                                      *       33
3      34  *                                                                                                      *       34
3      35  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *       35
3      36  *                                                                                                      *       36
3      37  *                                                                                                      *       37
3      38  *                                                                                                     X*       38
3      39  *                                                                                                    X *       39
3      40  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +X *       40
3      41  *                                                                                                   1  *       41
3      42  *                                                                                                  1   *       42
3      43  *                                                                                                 1    *       43
3      44  *                                                                                                 1    *       44
3      45  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    + 1  +  *       45
3      46  *                                                                                               1      *       46
3      47  *                                                                                              1       *       47
3      48  *                                                                                              1       *       48
3      49  *                                                                                             1        *       49
3      50  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  1 +    +  *       50
3      51  *                                                                                             1        *       51
3      52  *                                                                                             1        *       52
3      53  *                                                                                              1       *       53
3      54  *                                                                                              1       *       54
3      55  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +1   +  *       55
```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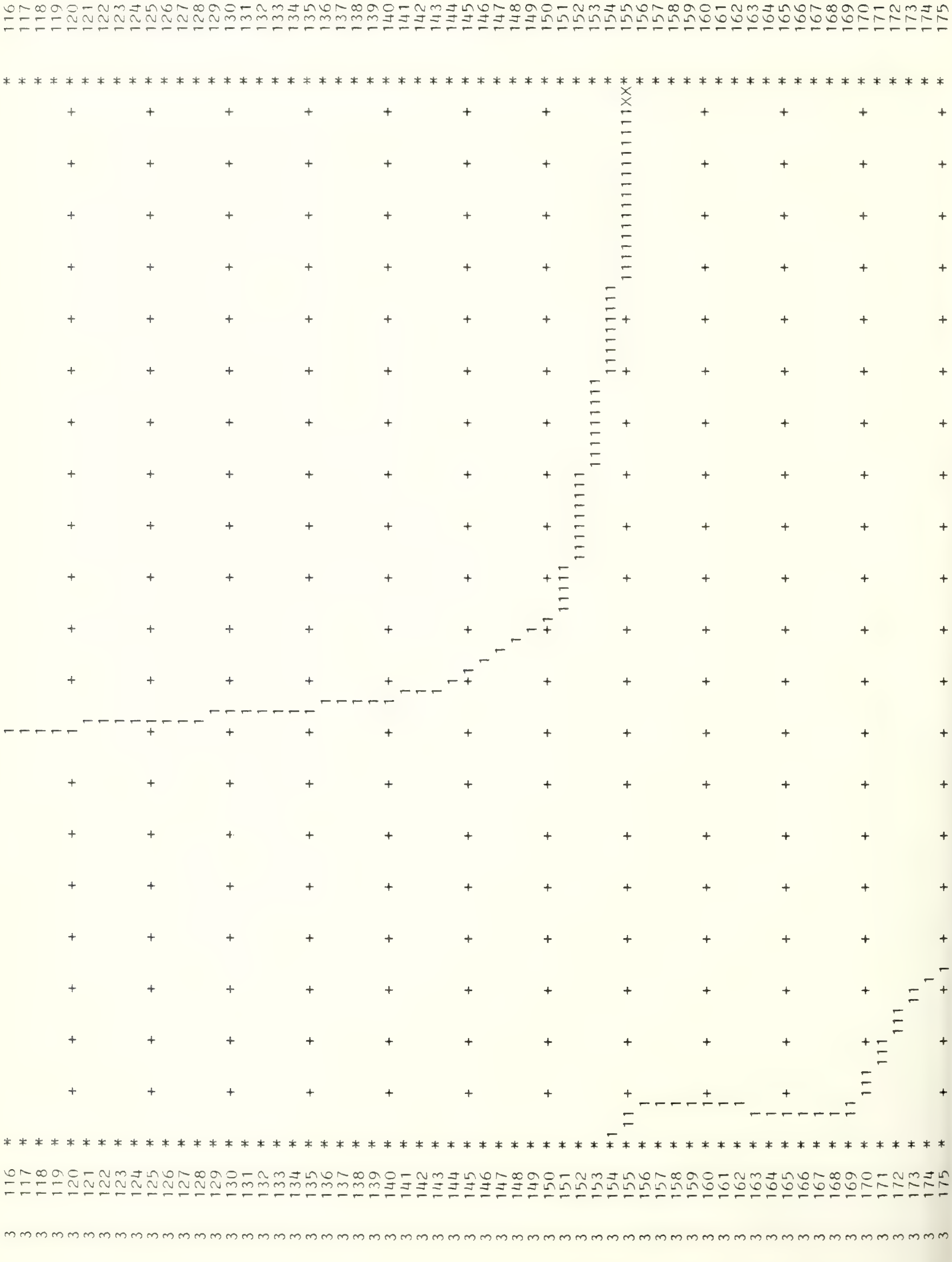
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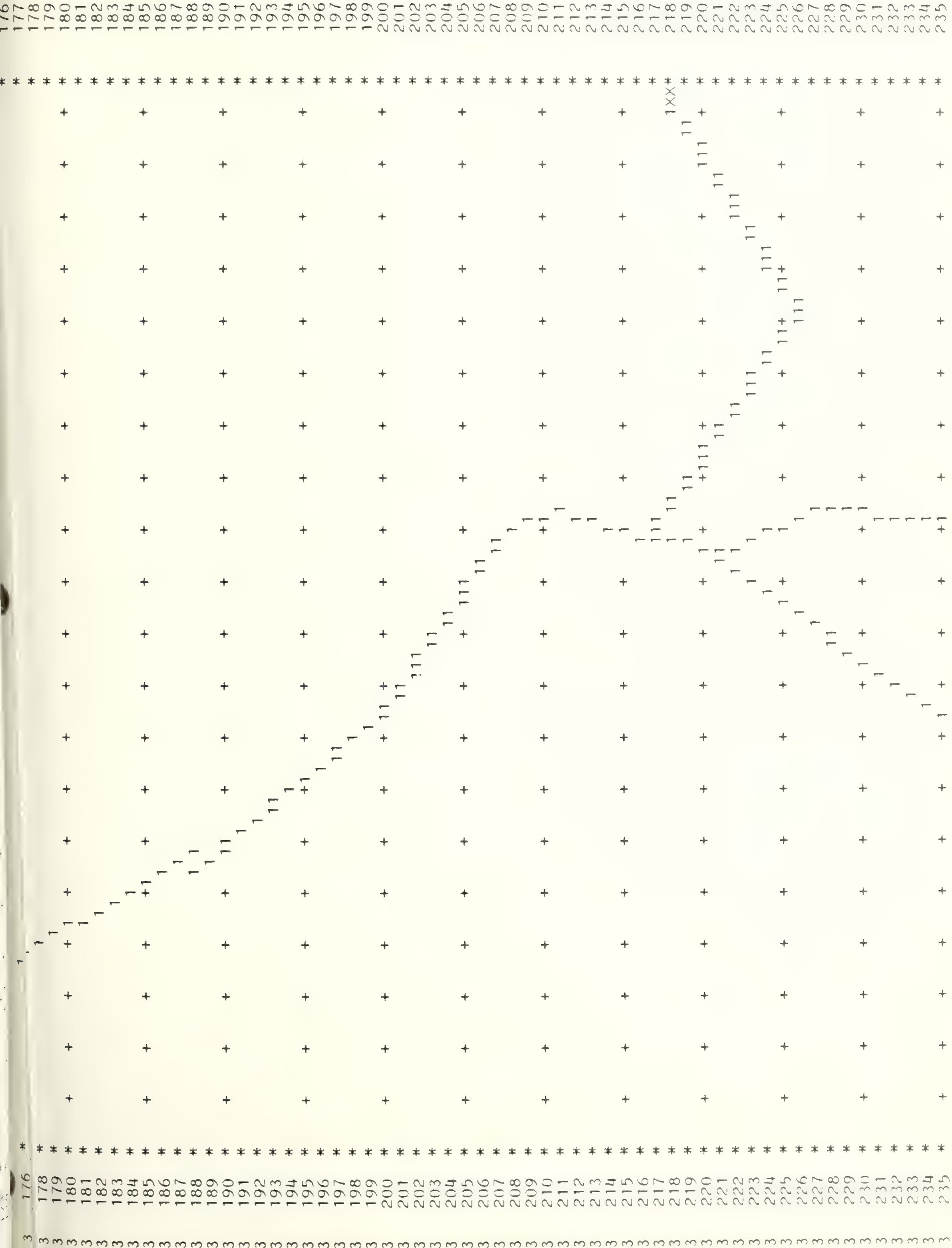
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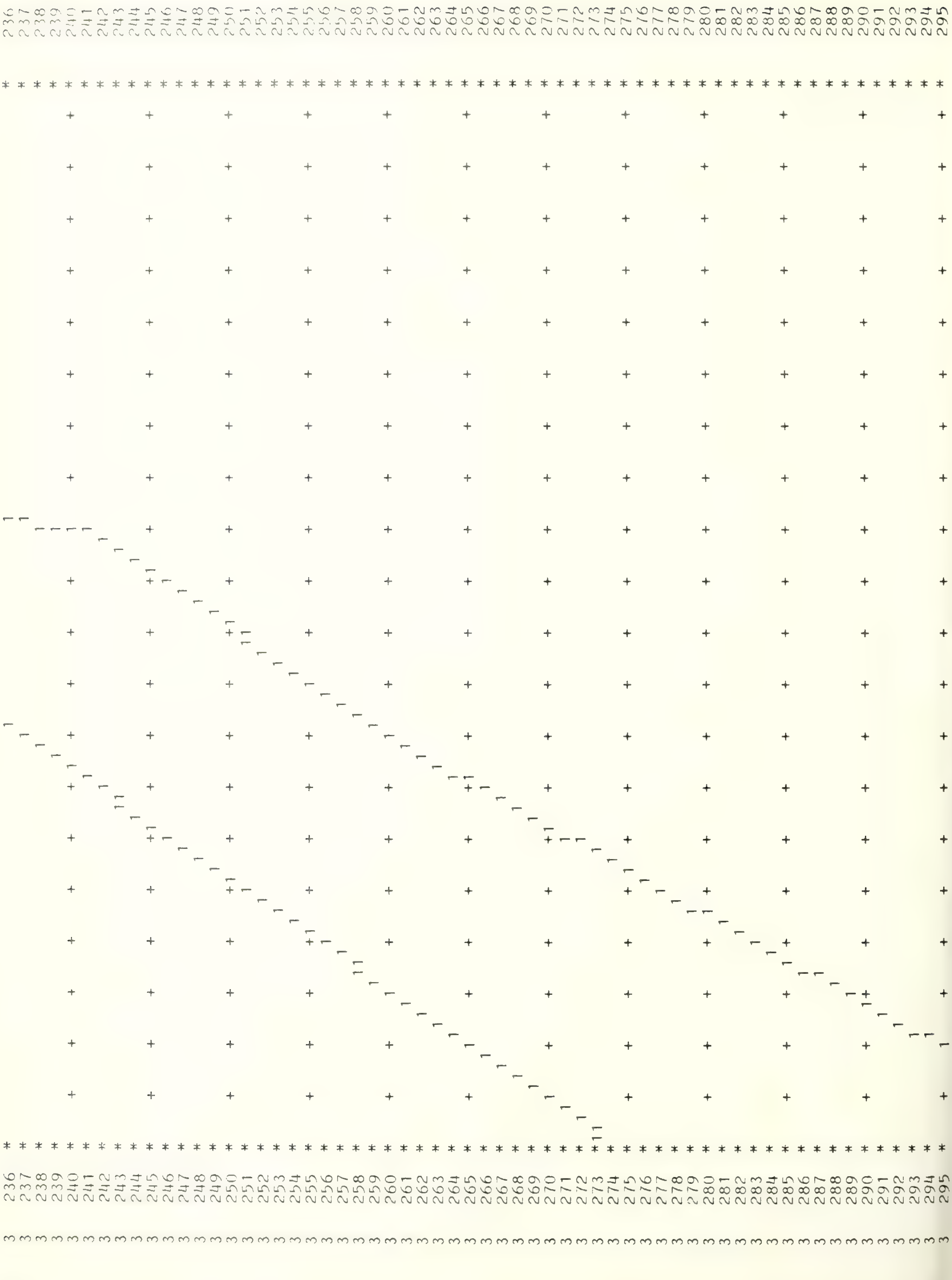
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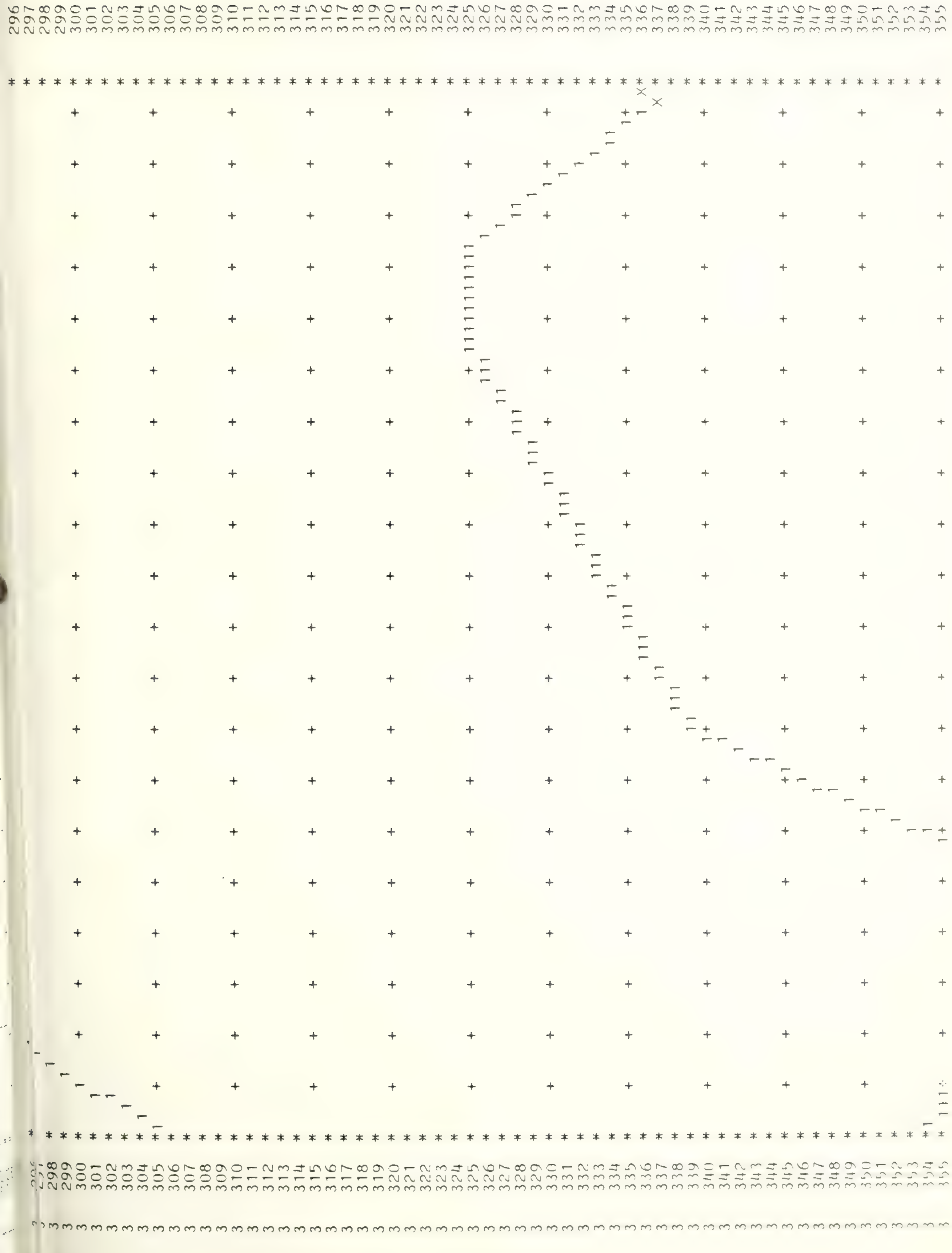
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```
3   356  *    111                    1                                                                          *   356
3   357  *       111                1                                                                           *   357
3   358  *          111             1                                                                           *   358
3   359  *             111         1                                                                            *   359
3   360  *    +    +    + 111+    1    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *   360
3   361  *                   111  1                                                                             *   361
3   362  *                      11                                                                              *   362
3   363  *                                                                                                      *   363
3   364  *                                                                                                      *   364
3   365  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *   365
3   366  *                                                                                                      *   366
3   367  *                                                                                                      *   367
3   368  *                                                                                                      *   368
3   369  *                                                                                                      *   369
3   370  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *   370
        <<<<<<<<<< OMITTING VACANT BLOCK >>>>>>>>>>
3   571  *                                                                                                      *   571
3   572  *                                                                                                      *   572
3   573  *                                                                                                      *   573
3   574  *                                                                                                      *   574
3   575  *    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +    +  *   575
3   576  *                                                                                                      *   576
3   577  *                                                                                                      *   577
3   578  *                                                                                                      *   578
3   579  *                                                                                                      *   579
3   580  *1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111XX*   580
3   581  *                                                                                                      *   581
         *****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|****|***
             305  310  315  320  325  330  335  340  345  350  355  360  365  370  375  380  385  390  395  400
```

```
                                                                                HANDY       13 MAR 80  23:25:09   63
                                                                                                HANDY   12.1393 SEC
DATE  13 MAR 80     TIME  23:25:09

END OF RUN
```

```
                                                                                    MERGE      08 FEB 80  01:34:38     0       1
                                                                                                              MERGE    0.0014 SEC
                                         INPUT CARD' FILES: INPUT ONE=WRIS01; INPUT TWO=WRIS01$


INPUT ONE
   REEL WRIS01


INPUT TWO
   REEL WRIS01
                                         INPUT CARD' HEADER ONE: FOREST=ST.JOE; MAP=59; LAYER=HABITAT$
                                         INPUT CARD' OPTIONS: SKIPS=3$
                                         INPUT CARD' HEADER TWO: FOREST=ST.JOE; MAP=113; LAYER=LAND USE$

PREPARING TO READ INPUT FILE FROM  REEL WRIS01
   POSITION 4   ST.JOE  HABITAT  MAP 59  TENSED   14 AUG 79  20:49:23    8086 WORDS  .101 SECONDS

NUMBER OF POLYGONS: 73   NUMBER OF X-Y POINTS: 7257   AVERAGE NUMBER OF X-Y POINTS PER POLYGON: 99

HEADER RECORD
   FOREST = ST.JOE;   MAP = 59;   LAYER = HABITAT;   LOCATION = TENSED;   SCALE = 31680;
   GEOGRAPHIC CONTROL POINTS = 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 101, 117, 102, 1857, 2460, 1831, 2463, 101;   GRID CONTROL POINTS = 39, 33, 25, 876, 1164, 892, 1180, 54;
   ZONE = 3;   STATE = IDAHO;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 2;   ENVELOPE = 98, 98, 1850, 2465;
   DATE WRITTEN = 14 AUG 79;   TIME WRITTEN = 20:49:23;   REEL NUMBER = C10598;   POSITION ON REEL = 2

LABELS
   1 PERIMETER   4 570
   2 530         5 520
   3 999

                                         INPUT CARD' OPTIONS: SKIPS=3$
                                         INPUT CARD' OUTPUT HEADER: FOREST=ST.JOE;LAYER=LAND USE;MAP=113$

PREPARING TO READ INPUT FILE FROM  REEL WRIS01
   POSITION 4   ST.JOE  HABITAT  MAP 59  TENSED   14 AUG 79  20:49:23    8086 WORDS  .078 SECONDS    (SKIPPED)
   POSITION 5   ST.JOE  LAND USE  MAP 113  TENSED  02 MAY 78  23:59:38    3829 WORDS  .126 SECONDS

NUMBER OF POLYGONS: 23   NUMBER OF X-Y POINTS: 3502   AVERAGE NUMBER OF X-Y POINTS PER POLYGON: 152

HEADER RECORD
   FOREST = ST.JOE;   MAP = 113;   LAYER = LAND USE;   LOCATION = TENSED;   SCALE = 31680;
   GEOGRAPHIC CONTROL POINTS = 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 100, 100, 105, 1840, 2460, 1835, 2460, 100;   GRID CONTROL POINTS = 917, 45, 36, 28, 19, 1226, 895, 1243;
   ZONE = 3;   STATE = IDAHO;   SCAN ROWS = 943;   SCAN COLUMNS = 1312;   MODE = 2;   ENVELOPE = 101, 97, 2462, 1840;
   DATE WRITTEN = 02 MAY 78;   TIME WRITTEN = 23:59:38;   REEL NUMBER = CC6938

LABELS
   1 PERIMETER   4 303
   2 999         5 PVT
   3 500
                                                                                                              MERGE    2.6317 SEC

OUTPUT HEADER
   FOREST = ST.JOE;   MAP = 113;   LAYER = LAND USE;   LOCATION = TENSED;   SCALE = 31680;
                                                       47.12500, 116.7500, 47.00000, 116.7500;
```

```
ST.JOE  MAP 59  HABITAT          ST.JOE  MAP 113  LAND USE                                 MERGE      08 FEB 80  01:35:25     2
   MAP CONTROL POINTS = 101, 117, 102, 1857, 2460, 1831, 2463, 101;   GRID CONTROL POINTS = 39, 33, 25, 876, 1164, 892, 1180, 54;
   ZONE = 3;   STATE = IDAHO;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 2;   ENVELOPE = 98, 98, 1850, 2465;
   DATE WRITTEN = 14 AUG 79;   TIME WRITTEN = 20:49:23;   REEL NUMBER = C10598;   POSITION ON REEL = 2
                                                                                                       MERGE    0.0570 SEC
                                                                                                       MERGE    0.1518 SEC
                                                                                                       MERGE    0.1114 SEC
```

```
ST.JOE  MAP 59  HABITAT           ST.JOE  MAP 113  LAND USE                                MERGE      08 FEB 80  01:35:27    2    3
                           LINE
              LABEL       LENGTH      AREA
 ITEM       LOCATION      (FEET)    (ACRES)    LABEL

   1      13.46  0.20     218100     65511     PERIMETER
   2      24.35 17.60       6641        49     530
   3       3.71 15.67       3013         8     530
   4      14.87 14.17     321737     31708     999
   5      24.36 13.92       5364        42     530
   6      23.24 12.28      37471      1218     999
   7      21.04 12.24       4800        29     530
   8       8.66 11.46       5711        44     530
   9       8.04 11.46       6906        54     520
  10       7.50 11.40       5301        30     530
  11       3.39 11.38      78542      6465     999
  12      23.38 10.70      27981       457     570
  13      11.25 10.66      13002       188     530
  14      12.09 10.14      19204        91     520
  15      11.54  9.99       8301        51     570
  16      22.05  9.74       9225        92     530
  17      11.38  9.36      13595       180     530
  18      18.99  8.92       6424        38     530
  19      20.01  8.78      47607       705     570
  20      21.86  8.76       5127        18     530
  21       5.36  8.70      15911       320     570
  22      11.45  8.65       7483        49     570
  23      23.81  8.61      12244        97     530
  24      22.30  8.59       4597        15     530
  25      21.46  8.58       5074        18     530
  26      22.55  8.48      13957        95     570
  27      21.71  8.46       7294        47     570
  28      23.33  8.40       5791        48     570
  29      12.02  8.22       8054        42     570
  30      11.21  8.07      21441       196     530
  31      19.15  8.06      10734        68     530
  32      22.10  7.98      14272        59     520
  33      22.31  7.64      10269        81     530
  34      19.12  7.61       7923        82     570
  35      18.59  7.39       6361        30     530
  36      20.35  7.38      27151       131     520
  37      20.20  7.10       5998        33     530
  38      18.24  7.07      12429       135     570
  39      17.55  6.89       8540        57     530
  40      24.31  6.47       5585        46     570
  41      17.40  6.41      10914        80     570
  42      16.90  5.90      11675       143     530
  43      15.33  5.25      10573       120     530
  44      19.93  4.99      50487       574     570
  45      18.95  4.96       6820        49     530
  46       8.92  4.86     148707     17979     999
  47      14.07  4.41       5353        31     570
  48      20.20  4.28      45980       340     520
  49      14.53  4.22       3928        17     570
  50      13.81  4.10       5830        34     530
  51      14.13  4.04      11994        45     520
  52      23.18  3.80      11882       107     530
  53      14.49  3.76       4412        23     530
  54      14.09  3.68       2886        11     530
```

```
ST.JOE  MAP 59  HABITAT          ST.JOE  MAP 113  LAND USE                        MERGE      08 FEB 80  01:35:27    3     4
                            LINE
              LABEL        LENGTH      AREA
 ITEM        LOCATION      (FEET)     (ACRES)    LABEL

   55      18.08   3.42      4529         16     570
   56      19.34   3.38      6463         33     570
   57      17.61   3.31      7447         46     530
   58      23.70   3.27     11196         84     530
   59      17.13   3.14      7884         61     570
   60      24.25   3.06     39909        440     570
   61      21.64   3.02     11865        109     530
   62      19.92   2.80      6919         35     570
   63      16.97   2.78      7145         52     530
   64      23.67   2.38      5123         35     520
   65      20.35   2.38      7307         52     570
   66      24.55   2.32      2694          8     530
   67      23.30   2.24      1277          2     570
   68      18.18   2.08     18499        261     570
   69      21.83   2.06     13785        142     530
   70      15.04   1.70     15874        176     570
   71      23.66   1.60     16380        359     999
   72      19.79   1.58     46013        761     530
   73      22.27   1.49     11912        170     570
   74      24.50  17.60      6562         50     500
   75       3.70  15.50      2807          7     500
   76      23.50  15.50     38422       1090     999
   77      14.00  15.00    163775      24207     999
   78      24.40  14.00      5429         42     500
   79      23.50  12.50     37525       1227     999
   80      21.00  12.30      4903         30     500
   81       4.00  12.00     78652       6447     999
   82       8.00  11.50     11718        121     500
   83      11.50   9.50     28660        797     303
   84      24.00   9.00     30981        599     500
   85       5.50   9.00     15875        319     500
   86      20.00   8.00     67832       1927     500
   87      18.40   7.70      9713         87     PVT
   88      24.50   6.50      5633         47     500
   89      22.00   6.00    164797       6345     999
   90       9.00   6.00    148530      17984     999
   91      15.50   5.30     10530        116     500
   92      14.00   4.00     10461        157     500
   93      21.00   3.00     69036       3367     500
   94      15.50   1.80     15935        175     500
   95      23.50   1.50     16293        357     PVT



AGGREGATE  AREAS  BY  LABEL

PERIMETER   65511
530          3000
999        115029
570          4024
520           755
500          6959
```

```
                                          ST.JOE  MAP 113  LAND USE                         MERGE      08 FEB 80  01:35:27    3      5
ST.JOE  MAP 59  HABITAT
AGGREGATE AREAS BY LABEL

303          797
PVT          444      ,

          196519 TOTAL

                                                                                                  MERGE     0.2461 SEC


DATE  08 FEB 80     TIME  01:35:27

END OF RUN
```

```
                                                                                      MOSAIC      11 MAR 80  18:29:40     0      1
                                                                                                          MOSAIC   0.0018 SEC
                                        INPUT CARD' FILES: INPUT ONE=WRIS01; INPUT TWO=WRIS01; OUTPUT=NONE$


INPUT ONE
   REEL WRIS01


INPUT TWO
   REEL WRIS01


OUTPUT
   'NONE'
                                        INPUT CARD' HEADER ONE: FOREST=ST.JOE; MAP-59; LAYER=HABITAT;
                                        INPUT CARD' STATE=IDAHO;ZONE=3$
                                        INPUT CARD' OPTIONS: SKIPS=3$
                                        INPUT CARD' HEADER TWO: FOREST=ST.JOE; MAP=113; LAYER=LAND USE;

PREPARING TO READ INPUT FILE FROM  REEL WRIS01
   POSITION 4   ST.JOE  HABITAT  MAP 59  TENSED   14 AUG 79  20:49:23    8086 WORDS  .108 SECONDS

NUMBER OF POLYGONS: 73   NUMBER OF X-Y POINTS: 7257   AVERAGE NUMBER OF X-Y POINTS PER POLYGON: 99

HEADER RECORD
   FOREST   ST.JOE;   MAP = 59;   LAYER   HABITAT;   LOCATION   TENSED;   SCALE   31680;
   GEOGRAPHIC CONTROL POINTS - 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS - 101, 117, 102, 1857, 2460, 1831, 2463, 101;   GRID CONTROL POINTS   39, 33, 25, 876, 1164, 892, 1180, 54;
   ZONE   3;   STATE = IDAHO;   SCAN ROWS = 1283;   SCAN COLUMNS - 928;   MODE = 2;   ENVELOPE - 98, 98, 1850, 2465;
   DATE WRITTEN - 14 AUG 79;   TIME WRITTEN - 20:49:23;   REEL NUMBER - C10598;   POSITION ON REEL - 2

LABELS
   1 PERIMETER   4 570
   2 530         5 520
   3 999

                                        INPUT CARD' STATE IDAHO;ZONE 3$
                                        INPUT CARD' OPTIONS: SKIPS 3$
                                        INPUT CARD' POLYGON SELECTIONS: INCLUDE AREAS GREATER THAN=5.09$

PREPARING TO READ INPUT FILE FROM  REEL WRIS01
   POSITION 4   ST.JOE  HABITAT  MAP 59  TENSED   14 AUG 79  20:49:23    8086 WORDS  .091 SECONDS      (SKIPPED)
   POSITION 5   ST.JOE  LAND USE  MAP 113  TENSED   02 MAY 78  23:59:38    3829 WORDS  .136 SECONDS

NUMBER OF POLYGONS: 23   NUMBER OF X-Y POINTS: 3502   AVERAGE NUMBER OF X-Y POINTS PER POLYGON: 152

HEADER RECORD
   FOREST   ST.JOE;   MAP   113;   LAYER = LAND USE;   LOCATION   TENSED;   SCALE   31680;
   GEOGRAPHIC CONTROL POINTS   47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS   100, 100, 105, 1840, 2460, 1835, 2460, 100;   GRID CONTROL POINTS   917, 45, 36, 28, 19, 1226, 895, 1243;
   ZONE   3;   STATE   IDAHO;   SCAN ROWS = 943;   SCAN COLUMNS   1312;   MODE   2;   ENVELOPE   101, 97, 2462, 1840;
   DATE WRITTEN   02 MAY 78;   TIME WRITTEN   23:59:38;   REEL NUMBER   CC6938
```

```
ST.JOE  MAP 59  HABITAT          ST.JOE  MAP 113  LAND USE                           MOSAIC     11 MAR 80  18:31:32    2     2
LABELS
   1 PERIMETER    4 303
   2 999          5 PVT
   3 500

                                                INPUT CARD' OUTPUT HEADER: FOREST=ST.JOE;LAYER=HABITAT/LAND USE;MAP-113;
                                                INPUT CARD' LOCATION TENSED;
                                                INPUT CARD' STATE-IDAHO; ZONE 3$
                                                INPUT CARD' MOSAIC OPTIONS: MINIMUM INPUT POLYGON AREA 2.0;
                                                INPUT CARD'                 MINIMUM OUTPUT POLYGON AREA=1.0;
                                                INPUT CARD'                 MINIMUM GROUND SLIVER WIDTH=150.0$

MAP 1 TO NEW MAP TRANSFORMATION:  X'=-.9847+1.0002*X+.0149*Y,  Y'=-.8155-.0055*X+.9953*Y

MAP 2 TO NEW MAP TRANSFORMATION:  X'=-.9734+1.0011*X+.0128*Y,  Y'=-.6246-.0133*X+.9939*Y

NEW MAP TO MAP 1 TRANSFORMATION:  X'=.9723+.9998*X-.0150*Y,  Y'=.8248+.0056*X+1.0047*Y

NEW MAP TO MAP 2 TRANSFORMATION:  X'=.9641+.9987*X-.0129*Y,  Y'=.6414+.0134*X+1.0060*Y
                                                                                                                MOSAIC   4.6894 SEC

MINIMUM INPUT POLYGON AREA = 2.00 ACRES.

MINIMUM OUTPUT POLYGON AREA = 1.00 ACRES.

MINIMUM GROUND SLIVER WIDTH = 150.00 FEET.

MINIMUM MAP SLIVER WIDTH = .06 INCHES.
                                                                                                                MOSAIC   1.0609 SEC


HABITAT

530   3000
999  57730
570   4024
520    755

     65509 TOTAL


LAND USE

999  57300
500   6959
303    797
PVT    444

     65500 TOTAL
                                                                                                                MOSAIC   0.0566 SEC


  FIRST SECOND                                                                  OUTPUT                                  CUMUL.
  INPUT  INPUT  MINX  MINY  MAXX  MAXY  ACRES  LABEL                              ITEM  MINX  MINY  MAXX  MAXY  ACRES  ACRES
```

```
ST.JOF  MAP 59  HABITAT                 ST.JOF  MAP 113                                  11 MAR 80   18:31:38    5    3
             2  2350  1613  2390  1706      50  500             1  2350  1613  2390  1706     46     46

   3             287  1444   306  1487       8  530
             3   286  1443   304  1485       7  500             2   287  1445   304  1485      6      6

   4              27    13  2389  1766   31708  999
             4  2024  1155  2388  1655    1090  999             3  2024  1156  2387  1655   1082   1082
             5    28   615  2388  1764   24207  999             4    28   615  2388  1764  24023  25105
            15  1697   658  1782   782      87  PVT             5  1697   659  1782   782     85  25190
            17  1357    13  2376  1107    6345  999             6  1358    13  2375  1107   6264  31454

   5            2331  1267  2384  1319      42  530
             6  2331  1269  2385  1320      42  500             7  2331  1269  2384  1319     38     38

   6            2044   872  2384  1315    1218  999
             7  2045   873  2384  1316    1227  999             8  2045   873  2384  1315   1205   1205

   7            1994  1108  2046  1157      29  530
             8  1992  1107  2046  1157      30  500             9  1994  1108  2046  1157     28     28

   8             748  1030   813  1081      44  530
            10   623  1031   812  1081     121  500            10   749  1031   812  1080     40     40

   9             672  1032   765  1083      54  520
            10   623  1031   812  1081     121  500            11   672  1032   765  1081     50     50

  10             622  1035   700  1075      30  530
            10   623  1031   812  1081     121  500            12   623  1035   700  1075     29     29

  11              13   589   709  1583    6465  999
             9    14   588   711  1581    6447  999            13    14   589   709  1581   6388   6388

  12            2191   669  2378  1022     457  570
            12  2191   670  2379  1021     599  500            14  2191   670  2378  1021    445    445

  13            1002   894  1113  1066     188  530
            11   999   668  1186  1065     797  303            15  1003   894  1113  1064    185    185

  14            1042   849  1185  1061      91  520
            11   999   668  1186  1065     797  303            16  1042   849  1185  1061     84     84

  15            1005   863  1112   931      51  570
            11   999   668  1186  1065     797  303            17  1005   863  1112   931     50     50

  16            2056   853  2191   905      92  530
            14  1525   461  2191   905    1927  500            18  2056   854  2191   904     90     90

  17            1001   766  1119   919     180  530
            11   999   668  1186  1065     797  303            19  1001   766  1119   919    179    179

  18            1789   743  1850   822      38  530
            14  1525   461  2191   905    1927  500            20  1789   743  1850   822     39     39

  19            1781   651  2088   907     705  570
            14  1525   461  2191   905    1927  500            21  1781   651  2088   905    695    695
```

```
ST.JOE  MAP 59  HABITAT               ST.JOE  MAP 113  LAND USE                                    MOSAIC       11 MAR 80  18:31:43    8      4
 FIRST  SECOND                                                                      OUTPUT                                             CUMUL.
 INPUT   INPUT  MINX  MINY  MAXX  MAXY  ACRES  LABEL                                  ITEM  MINX  MINY  MAXX  MAXY  ACRES  ACRES
   20           2091   722  2118   803     18   530
            14  1525   461  2191   905   1927   500                                    22  2091   722  2118   803     18     18

   21            404   688   508   889    320   570
            13   404   686   507   885    319   500                                    23   404   688   507   885    308    308

   22           1015   747  1119   819     49   570
            11   999   668  1186  1065    797   303                                    24  1015   747  1119   819     48     48

   23           2269   669  2359   822     97   530
            12  2191   670  2379  1021    599   500                                    25  2269   671  2359   822     94     94

   24           2133   721  2158   785     15   530
            14  1525   461  2191   905   1927   500                                    26  2133   721  2158   785     14     14

   25           2054   726  2073   804     18   530
            14  1525   461  2191   905   1927   500                                    27  2054   726  2073   804     17     17

   26           2106   701  2187   803     95   570
            14  1525   461  2191   905   1927   500                                    28  2106   701  2187   803     94     94

   27           2067   704  2114   805     47   570
            14  1525   461  2191   905   1927   500                                    29  2067   704  2114   804     46     46

   28           2219   721  2278   773     48   570
            12  2191   670  2379  1021    599   500                                    30  2219   721  2278   772     45     45

   29           1052   669  1131   761     42   570
            11   999   668  1186  1065    797   303                                    31  1052   669  1130   761     38     38

   30           1000   671  1184   916    196   530
            11   999   668  1186  1065    797   303                                    32  1000   671  1184   916    194    194

   31           1781   624  1892   736     68   530
            14  1525   461  2191   905   1927   500                                    33  1781   624  1892   736     68     68

   32           1994   655  2186   726     59   520
            14  1525   461  2191   905   1927   500                                    34  1994   655  2185   726     59     59

   33           2025   652  2186   696     81   530
            14  1525   461  2191   905   1927   500                                    35  2025   652  2184   696     81     81

   34           1780   621  1870   705     82   570
            14  1525   461  2191   905   1927   500                                    36  1780   621  1870   705     80     80

   35           1739   617  1835   663     30   530
            14  1525   461  2191   905   1927   500                                    37  1739   617  1835   663     29     29

   36           1833   606  1997   848    131   520
            14  1525   461  2191   905   1927   500                                    38  1833   607  1997   848    130    130

   37           1889   605  1981   632     33   530
            14  1525   461  2191   905   1927   500                                    39  1889   605  1981   632     31     31

   38           1667   558  1833   659    135   570
            14  1525   461  2191   905   1927   500                                    40  1667   561  1833   659    131    131
```

```
                                                                              MOSAIC      11 MAR 80   18:31:45     9
 ST.JOE   MAP 59   HABITAT          ST JOE   MAP 112   LAND USE -        OUTPUT                                              CUMUL.
 INPUT    INPUT    MINX   MINY   MAXX   MAXY   ACRES   LABEL               ITEM   MINX   MINY   MAXX   MAXY   ACRES   ACRES
   39              1627    559   1728    644      57   530
            14     1525    461   2191    905    1927   500                    41   1630    561   1728    635      52      52

   40              2317    521   2373    574      46   570
            16     2316    520   2375    573      47   500                    42   2317    521   2373    573      43      43

   41              1579    468   1689    591      80   570
            14     1525    461   2191    905    1927   500                    43   1580    468   1689    591      77      77

   42              1526    460   1673    555     143   530
            14     1525    461   2191    905    1927   500                    44   1526    461   1673    555     139     139

   43              1375    411   1526    465     120   530
            19     1376    413   1525    463     116   500                    45   1376    413   1525    463     112     112

   44              1774    198   2209    460     574   570
            21     1581     10   2370    458    3367   500                    46   1774    198   2208    458     556     556

   45              1777    363   1853    440      49   530
            21     1581     10   2370    458    3367   500                    47   1777    363   1853    440      47      47

   46                 4     16   1630   1060   17979   999
            18        5     18   1632   1060   17984   999                    48      5     18   1629   1060   17835   17835

   47              1277    329   1353    366      31   570
            20     1273    266   1372    368     157   500                    49   1277    329   1353    366      29      29

   48              1672      8   2077    367     340   520
            21     1581     10   2370    458    3367   500                    50   1672     11   2077    367     338     338

   49              1346    302   1374    360      17   570
            20     1273    266   1372    368     157   500                    51   1346    303   1372    359      14      14

   50              1275    266   1312    343      34   530
            20     1273    266   1372    368     157   500                    52   1275    268   1312    343      32      32

   51              1292    265   1374    365      45   520
            20     1273    266   1372    368     157   500                    53   1292    266   1372    363      43      43

   52              2180    183   2298    325     107   530
            21     1581     10   2370    458    3367   500                    54   2180    183   2298    323     103     103

   53              1333    265   1375    317      23   530
            20     1273    266   1372    368     157   500                    55   1333    266   1371    317      21      21

   54              1302    265   1331    299      11   530
            20     1273    266   1372    368     157   500                    56   1302    267   1331    299      10      10

   55              1675    239   1749    261      16   570
            21     1581     10   2370    458    3367   500                    57   1675    239   1749    260      13      13

   56              1825    181   1865    282      33   570
            21     1581     10   2370    458    3367   500                    58   1825    181   1865    282      33      33

   57              1600    207   1712    262      46   530
            21     1581     10   2370    458    3367   500                    59   1600    207   1712    261      45      45
```

```
ST.JOE  MAP 59  HABITAT          ST.JOE  MAP 113  LAND USE                                 MOSAIC     11 MAR 80  18:31:47   10      6
 FIRST  SECOND                                                             OUTPUT                                      CUMUL.
 INPUT   INPUT   MINX  MINY  MAXX  MAXY  ACRES  LABEL                       ITEM  MINX  MINY  MAXX  MAXY  ACRES  ACRES
   58            2214   153  2316   320     84  530
            21   1581    10  2370   458   3367  500                           60  2214   153  2316   320     86     86

   59            1581   189  1685   261     61  570
            21   1581    10  2370   458   3367  500                           61  1582   189  1685   261     59     59

   60            2005   124  2370   320    440  570
            21   1581    10  2370   458   3367  500                           62  2005   125  2370   320    433    433

   61            1981   178  2178   232    109  530
            21   1581    10  2370   458   3367  500                           63  1981   178  2178   232    109    109

   62            1873   137  1931   237     35  570
            21   1581    10  2370   458   3367  500                           64  1873   137  1931   237     34     34

   63            1582   168  1674   223     52  530
            21   1581    10  2370   458   3367  500                           65  1582   168  1674   223     50     50

   64            2234   124  2302   164     35  520
            21   1581    10  2370   458   3367  500                           66  2234   125  2302   164     34     34

   65            1881   113  1985   174     52  570
            21   1581    10  2370   458   3367  500                           67  1881   113  1985   174     52     52

   66            2352   125  2368   164      8  530
            21   1581    10  2370   458   3367  500                           68  2352   125  2367   163      6      6

   68            1679    12  1813   214    261  570
            21   1581    10  2370   458   3367  500                           69  1679    12  1813   214    260    260

   69            2022    65  2234   152    142  530
            21   1581    10  2370   458   3367  500                           70  2022    65  2234   152    140    140

   70            1329    16  1528   121    176  570
            22   1324    19  1528   120    175  500                           71  1340    19  1527   120    165    165

   71            2178     5  2368   128    359  999
            23   2176     7  2367   125    357  PVT                           72  2178     7  2367   125    348    348

   72            1745     9  2026   334    761  530
            21   1581    10  2370   458   3367  500                           73  1745    11  2026   334    753    753

   73            2043     7  2181   125    170  570
            21   1581    10  2370   458   3367  500                           74  2043    10  2178   125    164    164

OVERLAY DOES NOT INCLUDE 93 SPLINTER POLYGONS COMPRISING 159 ACRES
                                                                                                    MOSAIC    5.8445 SEC
```

```
ST.JOE   MAP 59   HABITAT                                    MOSAIC       11 MAR 80   18:31:48    11

            999   500  303  PVT

530              2375  558
999     56797                433
570              3776  135
520               654   84


ROW SUMS

530    2933
999   57230
570    3911
520     738

     64812  TOTAL


COLUMN SUMS

999   56797
500    6805
303     777
PVT     433

     64812  TOTAL
                                                                                  MOSAIC    0.0651 SEC
```

```
                                                                                      MOSAIC     11 MAR 80  18:31:48    11      8
ST.JOE  MAP 59  HABITAT          ST.JOE  MAP 113  LAND USE
DATE  11 MAR 80      TIME  18:31:48

END OF RUN
```

```
                                                                            PGRID      15 FEB 80  10:32:23     0
                                                     INPUT CARD' FILES: INPUT=WRIS01$


INPUT
   REEL WRIS01
                                                     INPUT CARD' HEADER: FOREST=ST.JOE; MAP=59; LAYER=HABITAT$
                                                     INPUT CARD' OPTIONS: SKIPS=3$
                                                     INPUT CARD' POLYGON SELECTIONS:

PREPARING TO READ INPUT FILE FROM  REEL WRIS01
   POSITION 4   ST.JOE  HABITAT  MAP 59  TENSED   14 AUG 79  20:49:23    8086 WORDS  .106 SECONDS

NUMBER OF POLYGONS: 73   NUMBER OF X-Y POINTS: 7257   AVERAGE NUMBER OF X-Y POINTS PER POLYGON: 99

HEADER RECORD
   FOREST = ST.JOE;   MAP = 59;   LAYER = HABITAT;   LOCATION = TENSED;   SCALE = 31680;
   GEOGRAPHIC CONTROL POINTS = 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 101, 117, 102, 1857, 2460, 1831, 2463, 101;   GRID CONTROL POINTS = 39, 33, 25, 876, 1164, 892, 1180, 54;
   ZONE = 3;   STATE = IDAHO;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 2;   ENVELOPE = 98, 98, 1850, 2465;
   DATE WRITTEN = 14 AUG 79;   TIME WRITTEN = 20:49:23;   REEL NUMBER = C10598;   POSITION ON REEL = 2

LABELS
   1 PERIMETER   4 570
   2 530         5 520
   3 999

                                                     INPUT CARD' INCLUDE ITEMS=2:8$

MAP ENVELOPE:

   LONGITUDE 117.00027 TO 116.81455
   LATITUDE 46.99842 TO 47.17013

OUTPUT FILE LABEL LIST
   1 530
   2 999


PGRID DONE.
384 CARDS REPRESENTING 7 POLYGONS WRITTEN TO FILE  11.
```

```
DATE  15 FEB 80     TIME  10:33:27
END OF RUN
```

```
THE FOLLOWING OUTPUT IS A LIST OF THE RID*GRID "D", "E", AND "F"
                       RECORDS PRODUCED BY "PGRID".

D F-CARDS       10                    G 47.17014 46.99843 117.00027 116.81456
E HABITAT
F 1    1.00000 116.75250  47.12155 116.75250  47.12169 116.75218  47.12184
F    116.75220  47.12198 116.75198  47.12213 116.75197  47.12227 116.75156
F     47.12256 116.75156  47.12271 116.75134  47.12285 116.75134  47.12300
F    116.75092  47.12335 116.74995  47.12329 116.75006  47.12300 116.74976
F     47.12286 116.74998  47.11644 116.75391  47.11650 116.75412  47.11664
F    116.75410  47.11995 116.75378  47.12010 116.75378  47.12024 116.75357
F     47.12039 116.75357  47.12053 116.75314  47.12082 116.75314  47.12097
F    116.75293  47.12111 116.75293  47.12126 116.75250  47.12155
F 1    1.00000 116.97043  47.10527 116.97021  47.10506 116.97043  47.10490
F    116.97043  47.10461 116.97064  47.10448 116.97064  47.10432 116.97084
F     47.10419 116.97095  47.10405 116.97116  47.10390 116.97116  47.10376
F    116.97137  47.10361 116.97137  47.10332 116.97159  47.10318 116.97159
F     47.10274 116.97180  47.10260 116.97180  47.10245 116.97223  47.10216
F    116.97244  47.10229 116.97244  47.10526 116.97043  47.10527
F 1    2.00000 116.84784  47.12492 116.84763  47.12508 116.83055  47.12488
F    116.83035  47.12503 116.81560  47.12482 116.81538  47.12497 116.80002
F     47.12483 116.79980  47.12497 116.79938  47.12491 116.79916  47.12477
F    116.79852  47.12477 116.79820  47.12491 116.78241  47.12471 116.78220
F     47.12485 116.76598  47.12473 116.76575  47.12486 116.75261  47.12471
F    116.75240  47.12486 116.75017  47.12480 116.74995  47.12466 116.74995
F     47.12329 116.75092  47.12335 116.75134  47.12300 116.75134  47.12285
F    116.75156  47.12271 116.75156  47.12256 116.75197  47.12227 116.75198
F     47.12213 116.75220  47.12198 116.75218  47.12184 116.75250  47.12169
F    116.75250  47.12140 116.75272  47.12140 116.75293  47.12126 116.75293
F     47.12111 116.75314  47.12097 116.75314  47.12082 116.75357  47.12053
F    116.75357  47.12039 116.75378  47.12024 116.75378  47.12010 116.75410
F     47.11995 116.75412  47.11664 116.75391  47.11650 116.74998  47.11644
F    116.74998  47.11588 116.74977  47.11572 116.75000  47.10773 116.74980
F     47.10751 116.75003  47.10089 116.74982  47.10066 116.74994  47.09518
F    116.75525  47.09525 116.75566  47.09494 116.75587  47.09494 116.75630
F     47.09465 116.75652  47.09465 116.75694  47.09436 116.75716  47.09436
F    116.75748  47.09422 116.75768  47.09428 116.75810  47.09393 116.75832
F     47.09399 116.75874  47.09370 116.75896  47.09370 116.75917  47.09357
F    116.75938  47.09355 116.75960  47.09341 116.75990  47.09341 116.76033
F     47.09312 116.76054  47.09312 116.76076  47.09297 116.76097  47.09297
F    116.76140  47.09268 116.76161  47.09268 116.76204  47.09239 116.76234
F     47.09239 116.76256  47.09225 116.76277  47.09224 116.76320  47.09195
F    116.76341  47.09195 116.76384  47.09166 116.76405  47.09166 116.76427
F     47.09152 116.76448  47.09152 116.76500  47.09123 116.76521  47.09122
F    116.76564  47.09093 116.76585  47.09093 116.76607  47.09079 116.76628
F     47.09079 116.76671  47.09050 116.76692  47.09050 116.76744  47.09021
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F    116.97073  47.10109 116.97095  47.10109 116.97159  47.10152 116.97180
F     47.10152 116.97223  47.10187 116.97223  47.10216 116.97180  47.10245
F    116.97180  47.10260 116.97159  47.10274 116.97159  47.10318 116.97137
F     47.10332 116.97137  47.10361 116.97116  47.10376 116.97116  47.10390
F    116.97095  47.10405 116.97084  47.10419 116.97064  47.10432 116.97064
F     47.10448 116.97043  47.10461 116.97043  47.10490 116.97021  47.10506
F    116.97043  47.10527 116.97244  47.10526 116.97266  47.10539 116.97307
F     47.10539 116.97328  47.10555 116.97392  47.10561 116.97414  47.10574
F    116.97456  47.10574 116.97478  47.10590 116.97519  47.10588 116.97551
F     47.10603 116.97594  47.10603 116.97615  47.10617 116.97636  47.10617
F    116.97658  47.10631 116.97699  47.10638 116.97722  47.10652 116.97763
F     47.10652 116.97784  47.10666 116.97827  47.10666 116.97849  47.10680
F    116.97891  47.10680 116.97911  47.10693 116.97964  47.10693 116.97986
F     47.10715 116.98029  47.10715 116.98050  47.10728 116.98071  47.10728
F    116.98093  47.10742 116.98135  47.10742 116.98155  47.10757 116.98198
F     47.10757 116.98219  47.10771 116.98262  47.10779 116.98283  47.10793
F    116.98337  47.10793 116.98357  47.10806 116.98399  47.10806 116.98421
F     47.10820 116.98463  47.10820 116.98485  47.10834 116.98528  47.10834
F    116.98549  47.10847 116.98590  47.10855 116.98611  47.10869 116.98654
F     47.10869 116.98686  47.10883 116.98729  47.10883 116.98750  47.10896
F    116.98772  47.10896 116.98793  47.10912 116.98834  47.10912 116.98856
F     47.10933 116.98898  47.10933 116.98920  47.10947 116.98962  47.10945
F    116.98984  47.10960 116.99025  47.10960 116.99046  47.10974 116.99100
F     47.10974 116.99121  47.10988 116.99142  47.10988 116.99164  47.11009
F    116.99207  47.11009 116.99226  47.11023 116.99269  47.11023 116.99290
F     47.11037 116.99333  47.11037 116.99355  47.11052 116.99397  47.11050
F    116.99419  47.11066 116.99471  47.11072 116.99492  47.11087 116.99535
F     47.11086 116.99556  47.11101 116.99599  47.11099 116.99620  47.11115
F    116.99663  47.11115 116.99683  47.11128 116.99704  47.11128 116.99725
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F      47.11150 116.99768  47.11150 116.99789  47.11163 116.99843  47.11163
F     116.99864  47.11177 116.99905  47.11177 116.99927  47.11191 117.00012
F      47.11191 116.99992  47.11832 117.00023  47.11847 117.00012  47.11874
F     116.99992  47.11890 116.99992  47.11940 117.00014  47.11954 117.00003
F      47.12401 117.00024  47.12416 117.00024  47.12488 116.99982  47.12517
F     116.99039  47.12509 116.99017  47.12523 116.97437  47.12505 116.97415
F      47.12520 116.95984  47.12508 116.95963  47.12523 116.94510  47.12505
F     116.94489  47.12518 116.92644  47.12502 116.92622  47.12517 116.91179
F      47.12505 116.91159  47.12518 116.91138  47.12497 116.90872  47.12498
F     116.90851  47.12514 116.89536  47.12500 116.89503  47.12514 116.88104
F      47.12494 116.88083  47.12509 116.86279  47.12491 116.86258  47.12506
F     116.84784  47.12492
F 1     1.00000 116.74994  47.09518 116.75006  47.09152 116.75027  47.09152
F     116.75049  47.09166 116.75154  47.09166 116.75175  47.09151 116.75504
F      47.09157 116.75546  47.09186 116.75545  47.09509 116.75525  47.09525
F     116.74994  47.09518
F 1     2.00000 116.76427  47.09152 116.76405  47.09166 116.76384  47.09166
F     116.76341  47.09195 116.76320  47.09195 116.76277  47.09224 116.76256
F      47.09225 116.76234  47.09239 116.76204  47.09239 116.76161  47.09268
F     116.76140  47.09268 116.76097  47.09297 116.76076  47.09297 116.76054
F      47.09312 116.76033  47.09312 116.75990  47.09341 116.75960  47.09341
F     116.75938  47.09355 116.75917  47.09357 116.75896  47.09370 116.75874
F      47.09370 116.75832  47.09399 116.75810  47.09393 116.75768  47.09428
F     116.75748  47.09422 116.75716  47.09436 116.75694  47.09436 116.75652
F      47.09465 116.75630  47.09465 116.75587  47.09494 116.75545  47.09496
F     116.75546  47.09186 116.75504  47.09157 116.75175  47.09151 116.75154
F      47.09166 116.75049  47.09166 116.74985  47.09116 116.74997  47.08453
F     116.74976  47.08432 116.75000  47.07747 116.74979  47.07733 116.75003
F      47.06781 116.74982  47.06767 116.74994  47.06291 116.75566  47.06303
F     116.75554  47.06743 116.75575  47.06764 116.75563  47.07341 116.75584
F      47.07355 116.75732  47.07362 116.75754  47.07339 116.76939  47.07355
F     116.76961  47.07341 116.77003  47.07376 116.77025  47.07376 116.77046
F      47.07391 116.77078  47.07390 116.77100  47.07405 116.77119  47.07405
F     116.77141  47.07419 116.77162  47.07419 116.77184  47.07434 116.77205
F      47.07433 116.77226  47.07448 116.77248  47.07448 116.77269  47.07469
F     116.77289  47.07469 116.77332  47.07498 116.77353  47.07497 116.77374
F      47.07512 116.77396  47.07512 116.77417  47.07526 116.77437  47.07526
F     116.77458  47.07539 116.77480  47.07539 116.77501  47.07555 116.77533
F      47.07561 116.77554  47.07576 116.77576  47.07576 116.77617  47.07605
F     116.77638  47.07603 116.77660  47.07619 116.77681  47.07617 116.77702
F      47.07632 116.77724  47.07632 116.77745  47.07646 116.77766  47.07646
F     116.77808  47.07683 116.77829  47.07683 116.77850  47.07697 116.77872
F      47.07697 116.77893  47.07710 116.77914  47.07710 116.77934  47.07726
F     116.77966  47.07724 116.77988  47.07739 116.78009  47.07739 116.78030
F      47.07761 116.78052  47.07761 116.78093  47.07790 116.78114  47.07788
F     116.78136  47.07803 116.78157  47.07803 116.78178  47.07817 116.78200
F      47.07817 116.78221  47.07831 116.78242  47.07831 116.78264  47.07846
F     116.78284  47.07852 116.78305  47.07867 116.78326  47.07867 116.78348
F      47.07881 116.78380  47.07881 116.78423  47.07910 116.78442  47.07910
F     116.78464  47.07924 116.78485  47.07924 116.78506  47.07938 116.78528
F      47.07938 116.78571  47.07974 116.78558  47.08313 116.78537  47.08313
F     116.78516  47.08327 116.78494  47.08327 116.78474  47.08342 116.78453
F      47.08342 116.78400  47.08371 116.78378  47.08371 116.78357  47.08386
F     116.78336  47.08386 116.78293  47.08415 116.78273  47.08415 116.78252
F      47.08429 116.78230  47.08429 116.78188  47.08458 116.78166  47.08458
F     116.78134  47.08473 116.78113  47.08473 116.78070  47.08502 116.78050
F      47.08502 116.78029  47.08517 116.78008  47.08517 116.77965  47.08546
F     116.77943  47.08546 116.77911  47.08560 116.77890  47.08560 116.77849
F      47.08589 116.77827  47.08589 116.77785  47.08618 116.77763  47.08620
F     116.77742  47.08633 116.77721  47.08633 116.77667  47.08662 116.77646
```

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                                    116.77583   47.08691 116.77562   47.08707
F    116.77541   47.08699 116.77498   47.08736 116.77477   47.08730 116.77423
F     47.08759 116.77402   47.08759 116.77382   47.08772 116.77361   47.08772
F    116.77318   47.08801 116.77296   47.08801 116.77254   47.08830 116.77232
F     47.08830 116.77211   47.08846 116.77179   47.08846 116.77138   47.08875
F    116.77116   47.08875 116.77095   47.08890 116.77074   47.08890 116.77031
F     47.08919 116.77010   47.08919 116.76988   47.08932 116.76967   47.08932
F    116.76915   47.08961 116.76894   47.08961 116.76872   47.08977 116.76851
F     47.08977 116.76808   47.09006 116.76787   47.09006 116.76765   47.09021
F    116.76744   47.09021 116.76692   47.09050 116.76671   47.09050 116.76628
F     47.09079 116.76607   47.09079 116.76585   47.09093 116.76564   47.09093
F    116.76521   47.09122 116.76500   47.09123 116.76448   47.09152 116.76427
F     47.09152
F 1    1.00000 116.78558   47.08313 116.78571   47.07974 116.78654   47.07973
F    116.78676   47.07959 116.79100   47.07964 116.79100   47.07993 116.79047
F     47.08022 116.79047   47.08035 116.79025   47.08051 116.79025   47.08064
F    116.79004   47.08080 116.79004   47.08095 116.78961   47.08122 116.78961
F     47.08138 116.78941   47.08151 116.78940   47.08167 116.78918   47.08180
F    116.78920   47.08195 116.78867   47.08232 116.78867   47.08246 116.78845
F     47.08260 116.78845   47.08275 116.78824   47.08289 116.78824   47.08304
F    116.78802   47.08318 116.78558   47.08313
F 1    1.00000 116.91656   47.07645 116.91605   47.07610 116.91615   47.07509
F    116.91594   47.07494 116.91615   47.07480 116.91615   47.07285 116.91879
F     47.07291 116.91901   47.07275 116.92059   47.07275 116.92102   47.07303
F    116.92102   47.07332 116.92145   47.07368 116.92145   47.07426 116.92166
F     47.07440 116.92166   47.07454 116.92229   47.07498 116.92229   47.07562
F    116.92250   47.07576 116.92250   47.07591 116.92293   47.07619 116.92293
F     47.07634 116.92271   47.07648 116.91656   47.07645
```

```
THE FOLLOWING OUTPUT IS A LIST OF THE LABELS PRODUCED BY "PGRID".

        530
        999
```

```
                                                                          POLLY       13 MAR 80  00:48:26     0     1
                                                                                                 POLLY    0.0013 SEC
                                  INPUT CARD' FILES: INPUT=WRIS01; OUTPUT=NONES


INPUT
   REEL WRIS01


OUTPUT
   'NONE'
                                  INPUT CARD' HEADER: FOREST=ST.JOE; MAP=59; LAYER=HABITAT$
                                  INPUT CARD' OPTIONS: SKIPS=2$
                                  INPUT CARD' HEADER UPDATES: FOREST=ST.JOE; MAP=59; LAYER=HABITAT;
                                  INPUT CARD' LOCATION=TENSED;
                                  INPUT CARD' 'TENSED HABITAT ST.JOE'
                                  INPUT CARD' MAP=059; FOREST=ST.JOE; LAYER=HABITAT; LOCATION=TENSED;
                                  INPUT CARD' MAP CONTROL POINTS= 101,117,102,1857,2460,1831,2463,101;
                                  INPUT CARD' GEOGRAPHIC CONTROL POINTS=47:00:00,117:00:00,47:07:30,117:00:00,
                                  INPUT CARD' 47:07:30,116:45:00,47:00:00,116:45:00;
                                  INPUT CARD' GRID CONTROL POINTS=39,33,25,876,1164,892,1180,54;
                                  INPUT CARD' STATE=IDAHO; ZONE=3; SCALE=31680; ENVELOPE=98,98,1850,2465$
                                  INPUT CARD' CORRECTIONS:

PREPARING TO READ INPUT FILE FROM  REEL WRIS01
   POSITION 3   ST.JOE  HABITAT  MAP 59  TENSED   26 JUL 77  02:10:21    37262 WORDS  1.273 SECONDS

HEADER RECORD
   FOREST = ST.JOE;   MAP = 59;   LAYER = HABITAT;   LOCATION = TENSED;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 0;
   ENVELOPE = 0, 0, 0, 0;   DATE WRITTEN = 26 JUL 77;   TIME WRITTEN = 02:10:21;   REEL NUMBER = CC3902
                                                                                                 POLLY    4.7051 SEC

UPDATED HEADER RECORD
   FOREST = ST.JOE;   MAP = 59;   LAYER = HABITAT;   LOCATION = TENSED;   SCALE = 31680;
   GEOGRAPHIC CONTROL POINTS = 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 101, 117, 102, 1857, 2460, 1831, 2463, 101;   GRID CONTROL POINTS = 39, 33, 25, 876, 1164, 892, 1180, 54;
   ZONE = 3;   STATE = IDAHO;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 2;   ENVELOPE = 98, 98, 1850, 2465;
   DATE WRITTEN = 26 JUL 77;   TIME WRITTEN = 02:10:21;   REEL NUMBER = CC3902



THE MAP SCALE IN THE HEADER RECORD IS 31680THE FOLLOWING TABLE SHOWS MAP SCALES BETWEEN EACH PAIR OF CONTROL POINTS.
THESE SCALES ARE CALCULATED FROM THE GEOGRAPHIC CONTROL POINTS IN THE HEADER RECORD.

                TO POINT 2     TO POINT 3     TO POINT 4

FROM POINT 1       31443          31774          31693

FROM POINT 2                      31672          31488

FROM POINT 3                                     31624

                                  INPUT CARD' ADDS=
                                  INPUT CARD' <1114,116:118>,<32,442:444>,<1172,458:466>,<1174,404:407>,
                                  INPUT CARD' <39,81:83>,<680:691,44>,679,45,<680:684,46>,<1178,157:158>,
                                  INPUT CARD' 1179,152,911,345,<35,286:291>,912,344,302,604,301,605,300,606,
```

F.46

```
ST.JOE   MAP 59   HABITAT                                                   POLLY      13 MAR 80   00:48:42     4      2
                                      INPUT CARD' <298:299,607>,<434:437,881>,<1013:1015,889>,1022,890,
                                      INPUT CARD' <1085:1086,890>,<1092:1093,891>;

///  SORTED ADDITIONS ///        68

ROW          COLUMNS

32            442-444

35            286-291

39            81-83

298-299       607

300           606

301           605

302           604

434-437       881

679           45

680           44 46

681           44 46

682           44 46

683           44 46

684           44 46

685-691       44

911           345

912           344

1013-1015     889

1022          890

1085-1086     890

1092-1093     891

1114          116-118

1172          458-466

1174          404-407

1178          157-158
1179          152
                                      INPUT CARD' DELETES=
INPUT CARD' 1107,121,<1108,122:123>,
INPUT CARD' <418,521:522>,
INPUT CARD' 1113,117,<1115,116:118>,
INPUT CARD' <680:684,45>,691,46,890,81,890,83,911,346,912,345,<509:510,453>,
INPUT CARD' 920,403,547,382$

///  SORTED DELETIONS ///        23

ROW          COLUMNS

418           521-522

509-510       453

547           382

680-684       45

691           46

890           81 83

911           346

912           345

920           403

1107          121

1108          122-123

1113          117

1115          116-118

                                        INPUT CARD' LABELS: LIST=

/// POLYGON LABEL DECK ///

A MASTER LABEL FILE IS NOT AVAILABLE

                                        INPUT CARD' 530 2435 1760,530 2020 710,
                                        INPUT CARD' 999 892 486,999 339 1138,999 1487 1417,
                                        INPUT CARD' 570 536 870,530 750 1140,520 804 1146,530 866 1146,
                                        INPUT CARD' 530 1125 1066,570 1154 999,520 1209 1014,530 1138 936,
                                        INPUT CARD' 570 1145 865,530 1121 807,570 1202 822,530 371 1567,
                                        INPUT CARD' 570 1504 170,530 1381 410,570 1407 441,520 1413 404,
                                        INPUT CARD' 530 1409 368,530 1449 376,570 1453 422,530 1533 525,
                                        INPUT CARD' 530 1690 590,570 1740 641,530 1755 689,570 1824 707,
                                        INPUT CARD' 530 1859 739,570 1912 761,530 1915 806,
                                        INPUT CARD' 530 1899 892,520 2035 738,570 2001 878,520 2210 798,
                                        INPUT CARD' 530 2231 764,530 2146 858,570 2171 846,530 2186 876,
                                        INPUT CARD' 530 2230 859,570 2255 848,530 2205 974,530 1697 278,
                                        INPUT CARD' 570 1713 314,530 1761 331,570 1808 342,570 1818 208,
                                        INPUT CARD' 520 2020 428,570 1934 338,530 1979 158,570 1992 280,
                                        INPUT CARD' 570 2035 238,530 1895 496,570 1993 499,530 2164 302,
                                        INPUT CARD' 570 2425 306,530 2318 380,530 2370 327,520 2367 238,
                                        INPUT CARD' 530 2455 232,570 2330 224,999 2366 160,530 2183 206,
                                        INPUT CARD' 570 2227 149,570 2431 647,570 2333 840,530 2381 861,
ST.JOE  MAP 59  HABITAT                                          POLLY      13 MAR 80  00:48:43    5       4
                           INPUT CARD' 570 2338 1070,530 2104 1224,999 2324 1228,530 2436 1392,
                           INPUT CARD' 530 2441 1755 $
```

```
///    74 SORTED LABELS ///

   DECK       LABEL      X        Y       LABEL
 POSITION     CODE     COORD    COORD

     74         1          1      641    PERIMETER
      1         2       2435     1760    530
     73         2       2441     1755    530
     17         2        371     1567    530
      5         3       1487     1417    999
     72         2       2436     1392    530
     71         3       2324     1228    999
     70         2       2104     1224    530
      9         2        866     1146    530
      8         5        804     1146    520
      7         2        750     1140    530
      4         3        339     1138    999
     69         4       2338     1070    570
     10         2       1125     1066    530
     12         5       1209     1014    520
     11         4       1154      999    570
     43         2       2205      974    530
     13         2       1138      936    530
     33         2       1899      892    530
     35         4       2001      878    570
     40         2       2186      876    530
      6         4        536      870    570
     14         4       1145      865    570
     68         2       2381      861    530
     41         2       2230      859    530
     38         2       2146      858    530
     42         4       2255      848    570
     39         4       2171      846    570
     67         4       2333      840    570
     16         4       1202      822    570
     15         2       1121      807    530
     32         2       1915      806    530
     36         5       2210      798    520
     37         2       2231      764    530
     31         4       1912      761    570
     30         2       1859      739    530
     34         5       2035      738    520
      2         2       2020      710    530
     29         4       1824      707    570
     28         2       1755      689    530
     66         4       2431      647    570
     27         4       1740      641    570
     26         2       1690      590    530
     25         2       1533      525    530
     55         4       1993      499    570
     54         2       1895      496    530
      3         3        892      486    999
     20         4       1407      441    570
     49         5       2020      428    520
     24         4       1453      422    570
     19         2       1381      410    530
     21         5       1413      404    520
     58         2       2318      380    530
```

23	2	1449	376	530
22	2	1409	368	530
47	4	1808	342	570
50	4	1934	338	570
46	2	1761	331	530
59	2	2370	327	530
45	4	1713	314	570
57	4	2425	306	570
56	2	2164	302	530
52	4	1992	280	570
44	2	1697	278	530
60	5	2367	238	520
53	4	2035	238	570
61	2	2455	232	530
62	4	2330	224	570
48	4	1818	208	570
64	2	2183	206	530
18	4	1504	170	570
63	3	2366	160	999
51	2	1979	158	530
65	4	2227	149	570

```
                                                                        POLLY     13 MAR 80  00:48:43    5
   THINNING:   6 SECONDS   3 PASSES                                                  POLLY    0.5869 SEC

                                                                                     POLLY    6.1518 SEC
```

```
ST.JOE  MAP 59  HABITAT                                                              POLLY      13 MAR 80  00:48:56   11     7
/// OUTPUT HEADER RECORD ///
   FOREST = ST.JOE;   MAP - 59;   LAYER - HABITAT;   LOCATION - TENSED;   SCALE - 31680;
   GEOGRAPHIC CONTROL POINTS - 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 101, 117, 102, 1857, 2460, 1831, 2463, 101;   GRID CONTROL POINTS - 39, 33, 25, 876, 1164, 892, 1180, 54;
   ZONE = 3;   STATE - IDAHO;   SCAN ROWS = 1283;   SCAN COLUMNS - 928;   MODE = 2;   ENVELOPE = 98, 98, 1850, 2465;
   DATE WRITTEN   26 JUL 77;   TIME WRITTEN = 02:10:21;   REEL NUMBER - CC3902

/// LOCAL LABEL LIST ///
   1 PERIMETER   4 570
   2 530         5 520
   3 999

   1     3  82.61 409.4426  174    14.51  1.06    1.00 24.65    1.01 18.57    13.46  0.20   PERIMETER
   2     3   2.52   0.3083   27    24.36 17.86   24.21 24.62   17.15 18.11    24.35 17.60   530

     ***** DEADEND ENCOUNTERED *****

          DEADEND AT ROW 1153,COLUMN  857  X= 2436, Y- 1759

          POLYGON LABEL AT ROW 1155,COLUMN  855

          LABEL NUMBER   73,LABEL      2,X=  2441,Y=  1755,MAP LABEL  530

********** THE FOLLOWING LABEL IS WITIN 5 HUNDRETHS OF THE DEAD END **********

          LABEL NUMBER     1,LABEL      2,X=  2435,Y-  1760,MAP LABEL  530
   3     3   1.14   0.0525   20     3.81 15.78    3.62  3.83   15.35 15.78     3.71 15.67   530
   4     3 121.87 198.1772 1019    15.37 18.40    1.00 24.65    1.04 18.57    14.87 14.17   999
   5     3   2.03   0.2600   11    24.61 14.20   24.09 24.61   13.69 14.21    24.36 13.92   530
   6     3  14.19   7.6152  196    23.26 13.70   21.24 24.63    9.72 14.17    23.24 12.28   999
   7     3   1.82   0.1809   26    21.25 12.55   20.74 21.25   12.06 12.56    21.04 12.24   530
   8     3   2.16   0.2729   23     8.89 11.73    8.29  8.95   11.22 11.74     8.66 11.46   530
   9     3   2.62   0.3351   37     8.09 11.75    7.53  8.47   11.24 11.75     8.04 11.46   520
  10     3   2.01   0.1860   29     7.53 11.66    7.04  7.81   11.25 11.66     7.50 11.40   530
  11     3  29.75  40.4037  379     3.46 15.85    1.00  7.90    6.74 16.73     3.39 11.38   999
  12     3  10.60   2.8549   76    23.90 11.18   22.74 24.63    7.68 11.21    23.38 10.70   570
  13     3   4.93   1.1730   75    11.29 11.34   10.85 11.96    9.86 11.59    11.25 10.66   530
  14     3   7.27   0.5715  138    12.10 10.35   11.23 12.69    9.42 11.54    12.09 10.14   520
  15     3   3.14   0.3191   70    11.54 10.24   10.89 11.97    9.55 10.25    11.54  9.99   570
  16     3   3.49   0.5769   20    22.74 10.00   21.39 22.74    9.52 10.03    22.05  9.74   530
  17     3   5.15   1.1219  102    11.39  9.81   10.86 12.04    8.56 10.12    11.38  9.36   530
  18     3   2.43   0.2404   55    19.00  9.18   18.74 19.36    8.39  9.18    18.99  8.92   530
  19     3  18.03   4.4059  301    20.22  9.52   18.67 21.72    7.47 10.04    20.01  8.78   570
  20     3   1.94   0.1119   41    21.91  9.01   21.76 22.04    8.20  9.01    21.86  8.76   530
  21     3   6.03   2.0019   17     5.92  9.76    4.90  5.92    7.75  9.78     5.36  8.70   570
  22     3   2.83   0.3046   68    11.47  8.83   11.01 12.04    8.37  9.11    11.45  8.65   570
  23     3   4.64   0.6036   72    23.82  9.02   23.54 24.48    7.68  9.21    23.81  8.61   530
  24     3   1.74   0.0929   32    22.30  8.73   22.18 22.43    8.19  8.83    22.30  8.59   530
  25     3   1.92   0.1122   32    21.58  9.01   21.39 21.60    8.23  9.02    21.46  8.58   530
  26     3   5.29   0.5923   73    22.72  9.01   21.91 22.73    7.99  9.03    22.55  8.48   570
  27     3   2.76   0.2942   61    21.79  9.03   21.53 22.00    8.00  9.03    21.71  8.46   570
  28     3   2.19   0.2973   24    23.48  8.70   23.04 23.66    8.18  8.72    23.33  8.40   570
  29     3   3.05   0.2607   30    12.09  8.49   11.37 12.17    7.61  8.53    12.02  8.22   570
  30     3   8.12   1.2237  110    11.22  8.39   10.86 12.68    7.62 10.09    11.21  8.07   530
  31     3   4.07   0.4249   76    19.23  8.25   18.67 19.80    7.20  8.32    19.15  8.06   530
  32     3   5.41   0.3659  126    22.12  8.09   20.81 22.72    7.52  8.23    22.10  7.98   520
  33     3   3.89   0.5068   57    22.39  7.94   21.12 22.72    7.50  7.94    22.31  7.64   530
  34     3   3.00   0.5095   64    19.24  7.94   18.66 19.57    7.17  8.03    19.12  7.61   570
```

```
ST.JOE   MAP 59   HABITAT                                                                          POLLY       13 MAR 80   00:49:17    16
ITEM TYPE LENGTH       AREA   PTS    FIRST POINT     RANGE OF X,       RANGE OF Y       LABEL LOC   LABEL
  35     3    2.41    0.1889   46    18.66   7.54    18.26 19.23      7.13   7.58     18.59   7.39   530
  36     3   10.28    0.8216  181    20.36   8.01    19.21 20.82      7.02   9.45     20.35   7.38   520
  37     3    2.27    0.2048   22    20.29   7.27    19.77 20.68      7.00   7.28     20.20   7.10   530
  38     3    4.71    0.8420   69    18.24   7.53    17.55 19.21      6.53   7.54     18.24   7.07   570
  39     3    3.23    0.3539   55    17.55   7.09    17.15 18.16      6.54   7.39     17.55   6.89   530
  40     3    2.12    0.2875    7    24.61   6.71    24.06 24.63      6.19   6.72     24.31   6.47   570
  41     3    4.13    0.4986   61    17.40   6.79    16.67 17.77      5.62   6.87     17.40   6.41   570
  42     3    4.42    0.8943   44    16.92   6.41    16.16 17.63      5.54   6.49     16.90   5.90   530
  43     3    4.00    0.7497   16    15.87   5.54    14.66 16.18      5.04   5.57     15.33   5.25   530
  44     3   19.12    3.5857  283    19.97   5.52    18.66 23.01      2.94   5.55     19.93   4.99   570
  45     3    2.58    0.3046   69    18.95   5.18    18.67 19.44      4.57   5.36     18.95   4.96   530
  46     3   56.33  112.3712  485    10.86  11.47     1.01 17.18      1.06  11.52      8.92   4.86   999
  47     3    2.03    0.1957   30    14.42   4.57    13.67 14.44      4.20   4.59     14.07   4.41   570
  48     3   17.42    2.1271  385    20.20   4.49    17.66 21.73      1.02   4.62     20.20   4.28   520
  49     3    1.49    0.1051   18    14.57   4.48    14.38 14.67      3.94   4.52     14.53   4.22   570
  50     3    2.21    0.2095   37    13.92   4.31    13.66 14.04      3.57   4.36     13.81   4.10   530
  51     3    4.54    0.2802   96    14.13   4.23    13.85 14.65      3.56   4.57     14.13   4.04   520
  52     3    4.50    0.6687   89    23.88   4.19    22.74 23.90      2.79   4.21     23.18   3.80   530
  53     3    1.67    0.1456   35    14.49   3.95    14.25 14.68      3.56   4.08     14.49   3.76   530
  54     3    1.09    0.0667   19    14.12   3.90    13.95 14.24      3.56   3.90     14.09   3.68   530
  55     3    1.72    0.0980   35    18.15   3.53    17.68 18.42      3.32   3.55     18.08   3.42   570
  56     3    2.45    0.2044   57    19.38   3.72    19.17 19.59      2.75   3.76     19.34   3.38   570
  57     3    2.82    0.2869   67    17.61   3.52    16.93 18.05      3.00   3.55     17.61   3.31   530
  58     3    4.24    0.5251   74    23.70   3.53    23.08 24.08      2.49   4.17     23.70   3.27   530
  59     3    2.99    0.3830   69    17.13   3.37    16.74 17.81      2.82   3.54     17.13   3.14   570
  60     3   15.12    2.7472  241    24.62   4.17    20.99 24.65      2.17   4.19     24.25   3.06   570
  61     3    4.49    0.6782   85    21.96   3.27    20.75 22.72      2.72   3.27     21.64   3.02   530
  62     3    2.62    0.2192   72    19.92   3.03    19.68 20.26      2.31   3.33     19.92   2.80   570
  63     3    2.71    0.3233   34    16.98   3.04    16.75 17.68      2.60   3.15     16.97   2.78   530
  64     3    1.94    0.2195   33    23.69   2.60    23.29 23.97      2.20   2.62     23.67   2.38   520
  65     3    2.77    0.3274   64    20.37   2.67    19.76 20.80      2.06   2.69     20.35   2.38   570
  66     3    1.02    0.0503   17    24.55   2.52    24.47 24.64      2.21   2.60     24.55   2.32   530
  67     3    0.48    0.0138   14    23.31   2.30    23.22 23.39      2.20   2.32     23.30   2.24   570
  68     3    7.01    1.6332  112    18.21   3.05    17.75 19.10      1.04   3.07     18.18   2.08   570
  69     3    5.22    0.8900   99    21.84   2.38    21.17 23.29      1.59   2.47     21.83   2.06   530
  70     3    6.01    1.1029   31    15.08   2.10    14.26 16.24      1.06   2.12     15.04   1.70   570
  71     3    6.20    2.2446   23    24.05   2.20    22.72 24.65      1.01   2.23     23.66   1.60   999
  72     3   17.43    4.7580  363    19.80   2.08    18.39 21.22      1.02   4.29     19.79   1.58   530
  73     3    4.51    1.0641   59    22.31   2.06    21.39 22.76      1.02   2.20     22.27   1.49   570
                                                                                                              POLLY     7.9383 SEC

 NUMBER OF LABELS READ          74
 NUMBER OF POLYGONS WRITTEN          73
AREA OF ENCLOSING POLYGON   409.4426
AREA OF ENCLOSED POLYGONS   409.4231
ENCLOSING POLYGON EXCEEDS ENCLOSED POLYGONS BY   0.020
THIS IS AN ERROR OF  1 PART  IN   20963

 MEASUREMENTS FOR CHECKING SCALE AND CONTROL POINTS
DISTANCE FROM CONTROL POINT  1 TO CONTROL POINT  3 IN MAP COORDINATES IS    2912
DISTANCE FROM CONTROL POINT  2 TO CONTROL POINT  4 IN MAP COORDINATES IS    2939
```

```
ST.JOE  MAP 59  HABITAT                                                         POLLY      13 MAR 80  00:49:30   19     9
                                                                                                POLLY    0.0110 SEC
DATE  13 MAR 80     TIME  00:49:30

END OF RUN
```

```
                                                                                      TONIC      14 MAR 80  05:00:19    0
                                    INPUT CARD' FILES: INPUT=WRIS01; OUTPUT=NONE$


INPUT
   REEL WRIS01


OUTPUT
   'NONE'
                                    INPUT CARD' HEADER: FOREST=ST.JOE; MAP=59; LAYER=HABITAT$
                                    INPUT CARD' OPTIONS: SKIPS=3$
                                    INPUT CARD' HEADER UPDATES: FOREST=ST.JOE; MAP=59; LAYER=HABITAT;

PREPARING TO READ INPUT FILE FROM  REEL WRIS01
   POSITION 4   ST.JOE  HABITAT  MAP 59  TENSED   14 AUG 79  20:49:23    8086 WORDS  .095 SECONDS

NUMBER OF POLYGONS: 73   NUMBER OF X-Y POINTS: 7257   AVERAGE NUMBER OF X-Y POINTS PER POLYGON: 99

HEADER RECORD
   FOREST = ST.JOE;   MAP = 59;   LAYER = HABITAT;   LOCATION = TENSED;   SCALE = 31680;
   GEOGRAPHIC CONTROL POINTS = 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 101, 117, 102, 1857, 2460, 1831, 2463, 101;   GRID CONTROL POINTS = 39, 33, 25, 876, 1164, 892, 1180, 54;
   ZONE = 3;   STATE = IDAHO;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 2;   ENVELOPE = 98, 98, 1850, 2465;
   DATE WRITTEN = 14 AUG 79;   TIME WRITTEN = 20:49:23;   REEL NUMBER = C10598;   POSITION ON REEL = 2

LABELS
   1 PERIMETER   4 570
   2 530         5 520
   3 999

                                    INPUT CARD' LOCATION=TENSED$

UPDATED HEADER RECORD
   FOREST = ST.JOE;   MAP = 59;   LAYER = HABITAT;   LOCATION = TENSED;   SCALE = 31680;
   GEOGRAPHIC CONTROL POINTS = 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 101, 117, 102, 1857, 2460, 1831, 2463, 101;   GRID CONTROL POINTS = 39, 33, 25, 876, 1164, 892, 1180, 54;
   ZONE = 3;   STATE = IDAHO;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 2;   ENVELOPE = 98, 98, 1850, 2465;
   DATE WRITTEN = 14 AUG 79;   TIME WRITTEN = 20:49:23;   REEL NUMBER = C10598;   POSITION ON REEL = 2

                                    INPUT CARD' LABEL COMBINATIONS: 500=510,520,530$

NEW LABEL LIST
   1 PERIMETER
   2 500
   3 999
   4 570


                                    INPUT CARD' NEW LABELS: 2,PVT; 3,880$

                                    INPUT CARD' NEW LABELS BY LOCATION: 999 1487 1417, 998 339 1138$

                                    INPUT CARD' NEW LABEL LOCATIONS: 4,1480,1410; 11,340,1140$
```

```
ST.JOE   MAP 59   HABITAT                                                        TONIC       14 MAR 80   05:01:15     2      2
                                  LINE
               LABEL             LENGTH       AREA
  ITEM        LOCATION           (FEET)      (ACRES)     LABEL

     1       13.46   0.20        218100       65511      PERIMETER
     2       24.35  17.60          6641          49      PVT
     3        3.71  15.67          3013           8      880
     4       14.80  14.10        321737       31708      999
     5       24.36  13.92          5364          42      500
     6       23.24  12.28         37471        1218      999
     7       21.04  12.24          4800          29      500
     8        8.66  11.46          5711          44      500
     9        8.04  11.46          6906          54      500
    10        7.50  11.40          5301          30      500
    11        3.40  11.40         78542        6465      998
    12       23.38  10.70         27981         457      570
    13       11.25  10.66         13002         188      500
    14       12.09  10.14         19204          91      500
    15       11.54   9.99          8301          51      570
    16       22.05   9.74          9225          92      500
    17       11.38   9.36         13595         180      500
    18       18.99   8.92          6424          38      500
    19       20.01   8.78         47607         705      570
    20       21.86   8.76          5127          18      500
    21        5.36   8.70         15911         320      570
    22       11.45   8.65          7483          49      570
    23       23.81   8.61         12244          97      500
    24       22.30   8.59          4597          15      500
    25       21.46   8.58          5074          18      500
    26       22.55   8.48         13957          95      570
    27       21.71   8.46          7294          47      570
    28       23.33   8.40          5791          48      570
    29       12.02   8.22          8054          42      570
    30       11.21   8.07         21441         196      500
    31       19.15   8.06         10734          68      500
    32       22.10   7.98         14272          59      500
    33       22.31   7.64         10269          81      500
    34       19.12   7.61          7923          82      570
    35       18.59   7.39          6361          30      500
    36       20.35   7.38         27151         131      500
    37       20.20   7.10          5998          33      500
    38       18.24   7.07         12429         135      570
    39       17.55   6.89          8540          57      500
    40       24.31   6.47          5585          46      570
    41       17.40   6.41         10914          80      570
    42       16.90   5.90         11675         143      500
    43       15.33   5.25         10573         120      500
    44       19.93   4.99         50487         574      570
    45       18.95   4.96          6820          49      500
    46        8.92   4.86        148707       17979      999
    47       14.07   4.41          5353          31      570
    48       20.20   4.28         45980         340      500
    49       14.53   4.22          3928          17      570
    50       13.81   4.10          5830          34      500
    51       14.13   4.04         11994          45      500
    52       23.18   3.80         11882         107      500
    53       14.49   3.76          4412          23      500
    54       14.09   3.68          2886          11      500
```

```
ST.JOE   MAP 59   HABITAT                                                              TONIC      14 MAR 80   05:01:16    2
                                 LINE
                LABEL           LENGTH       AREA
 ITEM         LOCATION          (FEET)     (ACRES)     LABEL

   55       18.08   3.42          4529          16      570
   56       19.34   3.38          6463          33      570
   57       17.61   3.31          7447          46      500
   58       23.70   3.27         11196          84      500
   59       17.13   3.14          7884          61      570
   60       24.25   3.06         39909         440      570
   61       21.64   3.02         11865         109      500
   62       19.92   2.80          6919          35      570
   63       16.97   2.78          7145          52      500
   64       23.67   2.38          5123          35      500
   65       20.35   2.38          7307          52      570
   66       24.55   2.32          2694           8      500
   67       23.30   2.24          1277           2      570
   68       18.18   2.08         18499         261      570
   69       21.83   2.06         13785         142      500
   70       15.04   1.70         15874         176      570
   71       23.66   1.60         16380         359      999
   72       19.79   1.58         46013         761      500
   73       22.27   1.49         11912         170      570



AGGREGATE  AREAS  BY  LABEL

PERIMETER   65511
500          3697
999         51265
570          4024
PVT            49
880             8
998          6465

           131019  TOTAL



DATE   14 MAR 80       TIME   05:01:16

END OF RUN
```

F.9 XCHG

```
                                                                          XCHG        15 FEB 80  12:16:42    0      1
                                         INPUT CARD' FILES: INPUT=WRIS01$


INPUT
   REEL WRIS01
                                         INPUT CARD' HEADER: FOREST-ST.JOE;LAYER-HABITAT;MAP-59$
                                         INPUT CARD' HEADER UPDATES: FOREST=ST.JOE;LAYER=HABITAT;MAP=59;
                                         INPUT CARD' LOCATION-TENSED$
                                         INPUT CARD' OPTIONS: SKIPS=3$
                                         INPUT CARD' POLYGON SELECTIONS: INCLUDE ITEMS=2:8$

PREPARING TO READ INPUT FILE FROM  REEL WRIS01
   POSITION 4   ST.JOE   HABITAT  MAP 59  TENSED   14 AUG 79  20:49:23    8086 WORDS   .103 SECONDS

NUMBER OF POLYGONS: 73   NUMBER OF X-Y POINTS: 7257   AVERAGE NUMBER OF X-Y POINTS PER POLYGON: 99

HEADER RECORD
   FOREST = ST.JOE;   MAP = 59;   LAYER = HABITAT;   LOCATION = TENSED;   SCALE = 31680;
   GEOGRAPHIC CONTROL POINTS = 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 101, 117, 102, 1857, 2460, 1831, 2463, 101;   GRID CONTROL POINTS = 39, 33, 25, 876, 1164, 892, 1180, 54;
   ZONE = 3;   STATE = IDAHO;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 2;   ENVELOPE = 98, 98, 1850, 2465;
   DATE WRITTEN = 14 AUG 79;   TIME WRITTEN = 20:49:23;   REEL NUMBER = C10598;   POSITION ON REEL = 2

LABELS
   1 PERIMETER   4 570
   2 530         5 520
   3 999


UPDATED HEADER RECORD
   FOREST = ST.JOE;   MAP = 59;   LAYER = HABITAT;   LOCATION = TENSED;   SCALE = 31680;
   GEOGRAPHIC CONTROL POINTS = 47.00000, 117.0000, 47.12500, 117.0000, 47.12500, 116.7500, 47.00000, 116.7500;
   MAP CONTROL POINTS = 101, 117, 102, 1857, 2460, 1831, 2463, 101;   GRID CONTROL POINTS = 39, 33, 25, 876, 1164, 892, 1180, 54;
   ZONE = 3;   STATE = IDAHO;   SCAN ROWS = 1283;   SCAN COLUMNS = 928;   MODE = 2;   ENVELOPE = 98, 98, 1850, 2465;
   DATE WRITTEN = 14 AUG 79;   TIME WRITTEN = 20:49:23;   REEL NUMBER = C10598;   POSITION ON REEL = 2

LABELS WILL BE WRITTEN TO THE EXCHANGE FILE.

CO-ORDINATES WRITTEN TO EXCHANGE FILE WILL BE ADJUSTED BY SUBTRACTING 97 FROM X AND 97 FROM Y.

DATE  15 FEB 80     TIME  12:19:03

END OF RUN
```

THE FOLLOWING IS A LIST OF THE UNIVERSAL DATA EXCHANGE

```
ST.JOE                                    TENSED   HABITAT
     7      2 31680      4       1      1  1753  2368 41469      1WRIS
     4     20  47000000 117000000       5  1760  47124992 117000000
  2363   1734  47124992 116750000  2366      4  47000000 116750000
530                         999
3   1    27      1 2338 1663 2324 1618 2365 1714     30
233916892339169123421693234216952344169723441699234817032348170523501707235017092
35417142363171323621709236517072363161823261619232416212324166723271669232716712
329167323291675233316792333168123351683233516852339168
93   2   20      1  274 1470  265 1438  286 1481      5
 2841481 2861478 2841476 2841472 2821470 2821468 2801466 2791464 2771462 2771460
 2751458 2751454 2731452 2731446 2711444 2711442 2671438 2651440 2651481 2841481
3   3 1019      2 1390 1320     3     7 2368 1760 19817
14401743144217451603174116051743174417391746174118911738189317401897173918991737
19051737190817392057173520591737221217342214173623381733234017352361173423631732
23631713235417142350170923501707234817052348170323441699234416972342169523421693
23391691233916872337168723351685233516832333168123331679232916752329167323271671
23271669232416672324162123261619236316182363161023651608236314972365149423631402
23651399236413232314132423101320230813202304131623021316229813122296131222931310
22911311228713062285130722811303227913032277130122751301227312992270129922661295
22641295226212932260129322561289225412892250128522471285224512832243128322391279
22371279223312752231127522291273222712732222126922201269221612652214126522121263
22101263220612592204125921991255219712552195125321931253218912492187124921851247
21831247217812432176124321741241217212412168123721661237216412352162123521581231
21551231215312292151122921471225214512252141122121391221213712192135121921301215
21281216212412112122121221201210211812102114120621121206210712022105120221031200
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☆ U.S. GOVERNMENT PRINTING OFFICE 1981 — 780-114/358 Region No. 8

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User's guide provides detailed information about the RID*POLY (WRIS) geographic information system. Explains how to prepare maps, digitize and scan input, and code control cards to operate the RID*POLY programs. Component programs in the system overlay map layers (MOSAIC), combine map layers (MERGE), edit map-files (TONIC), plot map-files (CHART), produce data in the Universal Data Exchange Format (XCHG), and convert data to grid format (PGRID).

KEYWORDS: WRIS, RID*POLY, RID*GRID, geographical information systems, computer mapping, management information systems

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

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THE EFFECTS OF FIRE AND OTHER DISTURBANCES ON SMALL MAMMALS AND THEIR PREDATORS: AN ANNOTATED BIBLIOGRAPHY

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THE EFFECTS OF FIRE AND OTHER DISTURBANCES ON SMALL MAMMALS AND THEIR PREDATORS: AN ANNOTATED BIBLIOGRAPHY

Compiler

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THE COMPILER

DR. CATHERINE H. REAM has her B.S., M.S. and Ph.D. degrees in zoology with a plant ecology minor from the University of Wisconsin in Madison. She has done research and published on turtles, lizards, loons, small mammals, and the effects of recreationists on wildlife in backcountry areas, and has worked on the vegetation of the Boundary Waters Canoe Area and the effects of fire and logging on elk and other wildlife. The present bibliography was accomplished through an Interpersonal Loan Agreement from the Forestry School of the University of Montana to the Fire Effects and Use Research and Development Program at the Northern Forest Fire Laboratory in Missoula.

RESEARCH SUMMARY

This report contains an annotated bibliography of the effects of fire, logging, grazing, and spraying on smal mammals and their predators. Each citation lists key words. A brief summary of the general effects of fire on some of the more common small mammals in western coniferous forests is included.

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INTRODUCTION

Recently, there has been increased interest in the ffects of disturbances on nongame species of wildlife uch as small mammals and their predators. Because ime and good library facilities are required to find these eferences, an annotated bibliography has been comiled to facilitate access to this information for land anagers. In addition, a brief summary of the infor-ation on the habitat requirements and the effects of re and other disturbances on some of the more-tudied small mammals has been included.

The major effect of disturbances such as fire, logging, razing, and herbicides on small mammals is the modication of vegetation. For this reason, references decribing specific habitat requirements of the common mall mammal species are included. Predators tend o be more closely tied to their food source than to other spects of their habitat (such as vegetation type), so the ain effects of disturbance may be through the effects n prey species. Therefore, publications dealing with redator-prey relationships, where small mammals are e prey species, have been included.

There are several small mammals, such as pikas and armot, for which I found no references related to fire, robably because these animals are associated with re-resistant, rocky habitats.

Bats are common small mammals for which I found no eferences on the effects of fire or other disturbances. ertainly, foliage-roosting species are influenced by fire logging, but this, apparently, has not been reearched.

Emphasis is on western coniferous forests, but pubcations specifically concerned with the effects of fire n small mammals have been included, regardless of eographical area. This bibliography should be useful r references published through 1979. Additional ferences will be graciously received.

This bibliography is the result of a literature search d the formation of a FAMULUS data file for the Fire fects R&D Program, Northern Forest Fire Laboratory. e data file will be utilized in preparation of guidelines d state-of-the-art publications dealing with the efcts of fire on resource production.

OVERVIEW OF FIRE EFFECTS

The responses of small mammal populations to fire d other disturbances are directly related to the modiation of vegetation and food sources. Disturbance at removes dominant vegetation results in increased mperature ranges and air movements at the ground rface. Moisture regimes are altered by changes in the ount of precipitation reaching the ground. Dew, aporation, and transpiration rates are also altered. few months after disturbance, there is a surge in the owth of herbaceous plants in response to these vironmental changes.

Short-term impacts of fire and other disturbance on imals include injury or death, loss of food and cover, d increased exposure to predation. The long-term sponse of many small mammal species is increased numbers, largely due to the surge in growth of herbaceous and seed-producing plants.

Much of the research on the effects of fire on small mammals was initiated because of the high small mammal populations following timber harvests and the resulting impacts on regeneration. Publications dealing with the effects on small mammals, of wildfire, or prescribed fire for big game habitat, are relatively scarce.

Although contradictions exist, general responses to the effects of fire can be predicted for most species. The following summaries are a synopsis of information from publications representing substantial research on the common species of the Rocky Mountain area for which information is available.

Shrews

(*Sorex* spp.)

Shrews generally require a mat of ground vegetation for cover. Shrews are insectivores, so they depend less on vegetation for food than do herbivorous species (Rickard 1960). Shrews are temporarily eliminated from areas where fire has removed the duff and ground vegetation, and will not return until a ground cover develops (Black and Hooven 1974). They are often associated with downed logs (Dimock 1974).

Rabbits and Snowshoe Hare

(*Sylvilagus* spp. and *Lepus americanus*)

Population highs of rabbits and showshoe hare are associated with shrubs and small, pole-sized confiers (Grange 1965). Hot fires that remove all cover make areas unsuitable as habitat until these successional stages are reached (Keith and Surrendi 1971). Slash piles can provide escape cover and improve the habitat of logged areas for cottontails (Costa and others 1976).

Beaver

(*Castor canadensis*)

High beaver populations have historically followed disturbances such as fire (Rowe and Scotter 1973) or logging (Patrick and Webb 1953) that initiate a successional sequence in which aspen is an intermediate stage. Beaver population peaks are often correlated with the establishment of aspen (Lawrence 1954; Patrick and Webb 1953). After a single generation, aspen is usually replaced by more tolerant climax species, and beaver populations decline (Lawrence 1954).

Chipmunks

(*Eutamias* spp.)

Chipmunks prefer partially open areas, but need the shelter provided by fallen trees, limbs, or shrubs. Fire and other disturbances may improve chipmunk habitat by creating openings, especially if these openings contain logging slash or rock outcrop cover (Davis 1976; Tevis 1956c). Chipmunks increase with the establishment of seed- and fruit-producing plants (Gashwiler 1970).

Ground Squirrels
(*Spermophilus* spp.)

Ground squirrels prefer open areas. They feed on plant species that grow in open habitat (Tevis 1953). Burrow systems provide protection from predators, so cover is not as important as it is for chipmunks, and large open areas can be invaded (Tevis 1956b; Gashwiler 1970b). Fire and other disturbances that remove the forest canopy improve the habitat for these animals (Davis 1976).

Red and Flying Squirrels
(*Tamiasciurus hudsonicus* and *Glaucomys* spp.)

Trees are essential for dens of flying squirrels and for dens and nests of red squirrels. These squirrels are displaced when fire or logging eliminates living trees from wide areas (Gashwiler 1970b) (Lyon and others 1978). Cavities in fire-killed trees may be used for dens (Burns, no date) if such snags are surrounded by living trees. Conifer seed is the primary food of red squirrels. Flying squirrels in some areas subsist largely on fungi (McKeever 1960), and may forage in fire-created openings.

Pocket Gophers
(*Thomomys* spp.)

Pocket gophers are favored by disturbance which removes the forest canopy, scarifies the soil, and results in the development of an herbaceous vegetation food source (Barnes 1974; Volland 1974). In unforested areas, grazing improves gopher habitat (Beuchner 1942). Protective burrow systems allow these animals to use large open areas, lacking protective cover.

Deer Mice
(*Peromyscus maniculatus*)

Deer mice are a pioneer species. They occur in most vegetation types during most stages of plant succession, but usually not in large numbers. Disturbances that result in early seral stages favor this species (Williams 1955). Deer mice are usually the most abundant small mammal in severely disturbed areas (Halvorson, in press; Dimock 1974). Their success on these sites is apparently due to their food habits (insects, wind-dispersed conifer seeds, and seeds that remain in t soil after burning), their nocturnal habits, errat movements (that provide protection from predator and lack of competition from other species.

Voles
(*Clethrionomys* spp. and *Microtus* spp.

Red-backed voles, *Clethrionomys* spp., and voles the genus *Microtus* are associated with the orga layer of the ground surface. Important elements their environment are a mat of ground cover, platal herbaceous plants, and moisture. A hot fire that de troys the surface organic layer will eliminate voles fro an area (Dimock 1974). Logging improves the growth forbs by decreasing competition for light and soil moi ture. After logging, increased numbers of *Microtus* c be expected, but *Clethrionomys* populations are usua decimated by the removal of the forest canopy (H vorson, in press; Halvorson, personal communicatio and resulting lack of free surface water (Odum 194 Occasionally, red-backed vole populations remain hi after logging until the slash is burned. After burnin populations decline (Gashwiler 1959).

PREDATORS

Numerical data on the effects of fire on diversity a numbers of predators are scarce. There are, howev some general observations. Marten need climax fore communities and will be eliminated by catastrophic fi They do benefit, however, from the vegetative mos resulting from regeneration following periodic sm fires (Koehler and Hornocker 1977), and may not adversely affected by selective timber harvesting (So tiere 1979). Hawks may temporarily congregate to hu in the vicinity of a recent burn (Baker 1940). Coyote a lion populations increase several years after fire response to increased numbers of prey (Edwards 195 A study of a raccoon family showed no change in the u of an area immediately after it burned (Sunquist 196

Although these observations are undoubtedly curate, I am not aware of any studies that actua document numerical increases in predators followi fire. The difficulties of accruing this kind of informati are several:

1. Even in dense populations, predators are ra compared to their prey.
2. Most predatory species are, by nature, very el sive.
3. Studies of predators, to be valid, need to be lon term (10 years or more).
4. The home range of many predators is so large th residence cannot usually be defined within a sing burned area.

ORGANIZATION OF THE BIBLIOGRAPHY

The publications are listed alphabetically by author. Each publication is numbered. The annotations relate the information pertaining to the subject of this bibliography and are not meant to be abstracts. Keywords are given for each publication. A numeric rating of 1, 2, or 3 is included with the keywords. Papers rated 1 pertain more closely to the subject of this bibliography than papers rated 3. The keywords are arranged after the author index by geographic area, land treatment, effects of treatments, small mammal population characteristics, plant associations, plant species, animal species, and general reference information. Common and scientific names are used in the species indexes. Mammalian nomenclature has been standardized and follows Jones, Carter, and Genoways (1975).

The indexing system can be used in several ways. It can be used to search for publications about deer mice, or to search several words simultaneously, such as deer mouse and Douglas-fir, and to check for matching reference numbers; or the author index could be used to look for reference numbers of publications of individuals known to have studied deer mice.

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2 AUTH ADAMS L.
DATE 1950.
TITL CONSUMPTION OF PONDEROSA PINE SEED BY SMALL MAMMALS.
PUBL USDA FOR. SERV., RES. NOTE NO. 80. 4P. NORTH. ROCKY MT. FOR. RANGE EXP. STN., MISSOULA, MONT.
ANNO AMOUNT OF PONDEROSA PINE SEED DESTROYED BY SMALL MAMMALS, ESPECIALLY WHITE-FOOTED MICE AND CHIPMUNKS, IS SUBSTANTIAL.
KEYS SMALL MAMMALS, FOOD HABITS, PONDEROSA PINE, IDAHO, MONTANA, WHITE-FOOTED MOUSE, CHIPMUNKS, 2

3 AUTH ADAMS L.
DATE 1959.
TITL AN ANALYSIS OF A POPULATION OF SNOWSHOE HARES IN NORTHWESTERN MONTANA.
PUBL ECOL. MONOGR. 29(2):141-170.
ANNO GENERAL LIFE HISTORY OF SNOWSHOE HARES. HARES PREFER TO STAY IN AREAS WHERE THE VEGETATION OFFERS PROTECTIVE COVER. WHEN THIS COVER BECOMES TOO DENSE, FOOD PLANTS CAN NO LONGER GROW THERE AND THE HARE HAVE TO MOVE INTO MORE OPEN AREAS TO FEED, INCREASING THEIR VULNERABILITY TO PREDATION. GREAT HORNED OWLS ARE THE MOST IMPORTANT PREDATOR.
KEYS SMALL MAMMALS, SNOWSHOE HARE, MONTANA, FOOD HABITS, POPULATION DENSITY, RAPTORS, GREAT HORNED OWL, PREDATORS, MINK, VEGETATION STRUCTURE, 2

4 AUTH ADAMS L., HANAVAN M.G., HOSLEY N. W., JOHNSON D. W.
DATE 1949.
TITL THE EFFECTS ON FISH, BIRDS AND MAMMALS OF DDT USED IN THE CONTROL OF FOREST INSECTS IN IDAHO AND WYOMING.
PUBL J. WILDL. MANAGE. 13(3):245-254.
ANNO 8.5 KG/HA DDT APPLIED TO FOREST LAND TO CONTROL TUSSOCK MOTH HAD NO APPARENT AFFECT ON SMALL MAMMALS EXCEPT FOR TREMORS IN SOME CHIPMUNKS AND A SHREW WHICH SHOWED TYPICAL SYMPTOMS OF DDT POISONING.
KEYS FISH, BIRDS, SMALL MAMMALS, INSECTICIDE, WYOMING, IDAHO, CHIPMUNKS, SHREWS, 3

5 AUTH ADELMAN E.
DATE 1979.
TITL A SURVEY OF NONGAME MAMMALS IN THE UPPER RATTLESNAKE CREEK DRAINAGE OF WESTERN MONTANA.
PUBL M.S. THESIS, UNIV. MONT., MISSOULA. 129P.
ANNO DISCUSSES THE IMPACTS OF LOGGING, FIRE, AND RECREATION ON SMALL MAMMALS AND PREDATORS.
KEYS SMALL MAMMALS, HABITAT, MONTANA, PREDATORS, FIRE, LOGGING, PLANT SUCCESSION, 2

6 AUTH AGEE J. K.
DATE 1974.
TITL ENVIRONMENTAL IMPACTS FROM FIRE MANAGEMENT ALTERNATIVES.
PUBL NATL. PARK SERVICE, 92P. WESTERN REGIONAL OFFICE, SAN FRANCISCO, CALIF.
ANNO DESCRIBES GENERAL DIRECT AND INDIRECT IMPACTS OF UNCONTROLLED FIRE ON WILDLIFE.
KEYS SMALL MAMMALS, LARGE MAMMALS, MORTALITY, WILDFIRE, SOIL CHARACTERISTICS, BIRDS, 2

7 AUTH AHLGREN C. E.
DATE 1963.
TITL SOME BASIC ECOLOGICAL FACTORS IN PRESCRIBED BURNING IN NORTHEASTERN MINNESOTA.
PUBL TALL TIMBERS FIRE ECOL. CONF. 2:143-149.
ANNO THE FIRST YEAR AFTER FIRE SEED EATING SMALL MAMMALS AND BIRDS INCREASED. THE SECOND YEAR THE NUMBERS OF THESE SPECIES WERE NEAR NORMAL. IN LABORATORY STUDIES PEROMYSCUS CONSUMED 185 JACK PINE SEEDS/DAY.
KEYS DEER MOUSE, PINE SISKIN, POPULATION DENSITY, FOOD HABITS, JACK PINE, MINNESOTA, SMALL MAMMALS, PRESCRIBED FIRE, 1, BIRDS

8 AUTH AHLGREN C. E.
DATE 1966.
TITL SMALL MAMMALS AND REFORESTATION FOLLOWING PRESCRIBED BURNING.
PUBL J. FOREST. 64(9):614-618.
ANNO RESPONSES OF DEER MICE, RED-BACKED VOLES AND LEAST CHIPMUNKS POPULATIONS IN A CUT AREA, TWO CUT AND BURNED AREAS, AND A CONTROL AREA, WERE DETERMINED BY SNAP TRAPPING FOR 3 CONSECUTIVE YEARS.
KEYS SMALL MAMMALS, RED-BACKED VOLES, DEER MOUSE, LEAST CHIPMUNK, FOOD HABITS, POPULATION DENSITY, POST-FIRE SUCCESSION, HABITAT, JACK PINE, LOGGING, MINNESOTA, PRESCRIBED FIRE, 1

9 AUTH AMBROSE H. W.
DATE 1972.
TITL EFFECT OF HABITAT FAMILIARITY AND TOE-CLIPPING ON RATE OF OWL PREDATION IN MICROTUS PENNSYLVANICUS.
PUBL J. MAMMAL. 53(4):909-912.
ANNO VOLES FAMILIAR WITH THEIR ENVIORNMENT WERE CAPTURED LESS READILY THAN ANIMALS NEWLY RELEASED. TOE-CLIPPING HAD NO SIGNIFICANT EFFECT ON RATE OF PREDATION.
KEYS SMALL MAMMALS, PREDATION, RAPTORS, BARN OWL, VOLES, 2

10 AUTH AMBROSE R. E.
DATE 1975.
TITL THE EFFECT OF CLEARCUTTING ON BIRD AND SMALL MAMMAL POPULATIONS.
PUBL PH.D. DISSERTATION. UNIV. TENN., KNOXVILLE. 287P.

ANNO THE WHITE-FOOTED MOUSE, EASTERN CHIPMUNK AND SHORT-TAILED SHREW WERE ALL MORE ABUNDANT ON CLEARCUTS THAN IN ADJACENT FOREST.
KEYS BIRDS, SMALL MAMMALS, CLEARCUT, TENNESSEE, RAPTORS, WHITE-FOOTED MOUSE, EASTERN CHIPMUNK, SHORT-TAILED SHREW, PREDATORS, LONG-TAILED WEASEL, POPULATION DENSITY, RESIDUE TREATMENTS, SELECTIVE CUT, 1

11 AUTH ANDELT W. F., GIPSON P. S.
DATE 1979.
TITL DOMESTIC TURKEY LOSSES TO RADIO-TAGGED COYOTES.
PUBL J. WILDL. MANAGE. 43(3)673-679.
ANNO DESCRIBES PREDATION ON DOMESTIC TURKEYS BY RADIO-COLLARED COYOTES.
KEYS PREDATORS, COYOTE, PREDATION, DOMESTIC TURKEY, NEBRASKA, 2

12 AUTH ANDELT W. F., GIPSON P. S.
DATE 1979.
TITL HOME RANGE, ACTIVITY, AND DAILY MOVEMENTS OF COYOTES.
PUBL J. WILDL. MANAGE. 43(4):944-951.
ANNO DESCRIPTION OF THE ACTIVITIES AND MOVEMENTS OF TOE-CLIPPED AND RADIO-EQUIPPED COYOTES.
KEYS PREDATORS, COYOTE, NEBRASKA, MOVEMENTS, HOME RANGE, HABITAT, 3

13 AUTH ANDERSON R. J., BARNES V. G., BRUCE A. M.
DATE 1976.
TITL A BIBLIOGRAPHY OF POCKET GOPHERS FAMILY GEOMYIDAE.
PUBL WEYERHAUSER FORESTRY PAPER NO. 16. 50P.
ANNO COMPREHENSIVE POCKET GOPHER BIBLIOGRAPHY.
KEYS BIBLIOGRAPHY, SMALL MAMMALS, POCKET GOPHERS, 2

14 AUTH AUMANN G. D.
DATE 1965.
TITL MICROTENE ABUNDANCE AND SOIL SODIUM LEVELS.
PUBL J. MAMMAL 46:594-604.
ANNO CORRELATES PEAK VOLE DENSITIES WITH THE ABUNDANCE OF SODIUM IN THE SOIL.
KEYS SMALL MAMMALS, VOLES, POPULATION DENSITY, SODIUM, 2

15 AUTH BAKER R. H.
DATE 1940.
TITL EFFECT OF BURNING AND GRAZING ON RODENT POPULATIONS.
PUBL J. MAMMAL. 21:223.
ANNO CONCLUDES THAT GRAZING AND BURNING, ESPECIALLY THE LATTER REDUCES THE SMALL RODENT POPULATION. DESCRIBES THE ATTRACTION OF HAWKS TO WINTER BURNS. SHREWS WERE NOT CAUGHT IN TRAPS BUT CONSTITUTED 41% OF MAMMALIAN REMAINS IN OWL PELLETS FROM THE SAME AREAS.
KEYS SMALL MAMMALS, HARVEST MOUSE, NORTHERN PIGMY MOUSE, COTTON RAT, RAPTORS, GRASSLAND, GRAZING, POPULATION DENSITY, TEXAS, PREDATION, PRESCRIBED FIRE, 2

16 AUTH BAKER W. W.
DATE 1973.
TITL LONGEVITY OF LIGHTNING-STRUCK TREES AND NOTES ON WILDLIFE USE.
PUBL TALL TIMBERS FIRE ECOL. CONF. 13:497-504.
ANNO SMALL MAMMALS USE BURNED OUT ROOT SYSTEMS OF LIGHTNING KILLED TREES.
KEYS SNAGS, BIRDS, SMALL MAMMALS, REPTILES, 3

17 AUTH BARMORE W. J. JR., TAYLOR D., HAYDEN P.
DATE 1976.
TITL ECOLOGICAL EFFECTS AND BIOTIC SUCCESSION FOLLOWING THE 1974 WATERFALLS CANYON FIRE IN GRAND TETON NATIONAL PARK.
PUBL RESEARCH PROG. REP. 1974-1975. GRAND TETON NATIONAL PARK. 99P.
ANNO LIVE TRAPPING DATA INDICATE THAT FIRE CAUSED A CHANGE IN THE SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF SMALL MAMMALS.
KEYS SMALL MAMMALS, BIRDS, MORTALITY, SPECIES COMPOSITION, POPULATION DENSITY, GRAND TETON NATIONAL PARK, POST-FIRE SUCCESSION, WILDFIRE, 2

18 AUTH BARNES V. G. JR.
DATE 1974
TITL RESPONSE OF POCKET GOPHER POPULATIONS TO SILVICULTURAL PRACTICES IN CENTRAL OREGON.
PUBL IN WILDLIFE AND FOREST MANAGEMENT IN THE PACIFIC NORTHWEST. P. 267-276. H.C. BLACK ED., 1973 SYMP. ORE. STATE UNIV., CORVALLIS.
ANNO RECOMMENDS ASSESSING GOPHER POPULATIONS BEFORE LOGGING. IN AREAS WHERE GOPHERS MAY PREVENT REFORESTATION, APPROPRIATE SILVICULTURAL PRACTICES SHOULD BE USED.
KEYS OREGON, LOGGING, CLEARCUT, HABITAT, 1

19 AUTH BECK A. M., VOGL R. J.
DATE 1972.
TITL THE EFFECTS OF SPRING BURNING ON RODENT POPULATIONS IN A BRUSH PRAIRIE SAVANNA.
PUBL J. MAMMAL. 53(2):336-346.
ANNO FIRE WAS USED TO CONVERT A FOREST WITH SUPPRESSED PRAIRIE UNDERSTORY BACK TO BRUSH PRAIRIE SAVANNA. THE SMALL MAMMAL RESPONSE WAS CONSIDERED TO BE A RESULT OF THE CHANGE IN VEGETATION. PEROMYSCUS LEUCOPUS AND CLETHRIONOMYS GAPPERI WERE BEST ADAPTED TO THE UNBURNED FOREST AND P. MANICULATUS AND SPERMOPHILUS TRIDECEMLINEATUS TO FIRE MAINTAINED PRAIRIE.
KEYS SMALL MAMMALS, WHITE-FOOTED MOUSE, DEER MOUSE, THIRTEEN-LINED GROUND SQUIRREL, RED-BACKED VOLES, HABITAT, FOOD HABITS, POPULATION DENSITY, SPECIES DIVERSITY, FIRE DISCLIMAX, BRUSH-GRASS, WISCONSIN, MORTALITY, RAPTORS, PREDATION, VEGETATION STRUCTURE, PRESCRIBED FIRE, 1

20 AUTH BENDELL J. F.
DATE 1961.
TITL SOME FACTORS AFFECTING THE HABITAT SELECTION OF THE WHITE-FOOTED MOUSE.
PUBL CAN. FIELD-NAT. 75(4):244-255.
ANNO DISTRIBUTION OF WHITE-FOOTED MOUSE STUDIED IN RELATION TO COVER, FOOD AND POPULATION STRUCTURE. MICE SELECTED ROCK COVER AND AVOIDED GRASSFORM COVER. IN DENSE POPULATIONS, LESS DESIRABLE HABITATS WERE FILLED. HABITAT SELECTION APPEARED TO BE MORE FOR PROTECTIVE COVER, THAN FOR FOOD.
KEYS SMALL MAMMALS, WHITE-FOOTED MOUSE, FOOD HABITS, VEGETATION STRUCTURE, ONTARIO, 2

21 AUTH BENDELL J. F.
DATE 1974.
TITL EFFECT OF FIRE ON BIRDS AND MAMMALS.
PUBL IN FIRE AND ECOSYSTEMS. P. 73-138. T. T. KOZLOWSKI/C.E. ALGREN, EDS. ACADEMIC PRESS, NEW YORK.

ANNO THOROUGH REVIEW OF LITERATURE COVERING VIRTUALLY ALL EFFECTS OF FIRE ON WILDLIFE.
KEYS SMALL MAMMALS, BIRDS, FIRE, POPULATION DENSITY, POST-FIRE SUCCESSION, HABITAT, BIBLIOGRAPHY, MICROCLIMATE, VEGETATION STRUCTURE, MOSAIC, PREDATION, RAPTORS, PREDATORS, LARGE MAMMALS, FOOD HABITS, SPECIES COMPOSITION, NUTRIENTS, 1

22 AUTH BERGSTROM D.
DATE 1979.
TITL SMALL MAMMALS TRAFFIC IN TRUFFLES
PUBL FOR. RES. WEST JAN. 79:1-3. USDA FOR. SERV., PAC. NORTHWEST FOR. AND RANGE EXP. STN., PORTLAND, ORE.
ANNO SMALL MAMMALS' CONSUMPTION OF TRUFFLES MAY BE IMPORTANT IN SPREADING THE SPORES OF MYCORRHIZAL FUNGI WHICH ARE IMPORTANT FOR THE SURVIVAL AND GROWTH OF TREES ON SOME UNFAVORABLE SITES.
KEYS SMALL MAMMALS, FOOD HABITS, 3, MYCORRHIZAL FUNGI

23 AUTH BERNARD S. R., BROWN K. F.
DATE 1977.
TITL DISTRIBUTION OF MAMMALS, REPTILES, AND AMPHIBIANS BY BLM PHYSIOGRAPHIC REGIONS AND A. W. KUCHLER'S ASSOCIATIONS FOR THE ELEVEN WESTERN STATES.
PUBL USDI-BLM TECH. NOTE 301, 169P.
ANNO INFORMATION ON HABITAT REQUIREMENTS, PHYSIOGRAPHIC REGIONS, ASSOCIATION NUMBERS, AND STATES WHERE EACH SPECIES OCCURS.
KEYS SMALL MAMMALS, PREDATORS, HABITAT, LIFE HISTORY, WESTERN U.S., 2

24 AUTH BISWELL H. H.
DATE 1963.
TITL RESEARCH IN WILDLAND FIRE ECOLOGY IN CALIFORNIA.
PUBL TALL TIMBERS FIRE ECOL. CONF. 2:63-97.
ANNO HARVEST MICE, PINYON MICE AND DEER MICE WERE TRAPPED IN UNTREATED AREAS BUT NO MICE WERE TRAPPED IN THE AREA OF THE PRESCRIBED BURN. SUGGESTS THAT BURNING DESTROYS COVER FOR HIDING AND LEAVES RODENTS VULNERABLE TO PREDATION BY OWLS.
KEYS HARVEST MOUSE, PINON MOUSE, DEER MOUSE, OWLS, PREDATION, POPULATION DENSITY, PONDEROSA PINE, MANZANITA, CALIFORNIA, SMALL MAMMALS, PRESCRIBED FIRE, 2

25 AUTH BLACK H. C., DIMOCK E. J., EVANS J., ROCHELLE J. A.
DATE 1979.
TITL ANIMAL DAMAGE TO CONIFEROUS PLANTATIONS IN OREGON AND WASHINGTON . PART 1. A SURVEY, 1963-1975.
PUBL RES. BULL. 25. ORE. STATE UNIV., SCH. OF FOR., CORVALLIS.
ANNO DESCRIPTION OF ANIMAL DAMAGE TO CONIFEROUS PLANTATIONS IN OREGON AND WASHINGTON.
KEYS SMALL MAMMALS, LARGE MAMMALS, BIRDS, DAMAGE, OREGON, WASHINGTON, DOUGLAS-FIR, PONDEROSA PINE, 3

26 AUTH BLACK H. C., HOOVEN E. H.
DATE 1974.
TITL RESPONSE OF SMALL MAMMAL COMMUNITIES TO HABITAT CHANGES IN WESTERN OREGON.
PUBL IN WILDLIFE AND FOREST MANAGEMENT IN THE PACIFIC NORTHWEST. P. 177-186. H. C. BLACK ED., PROC. 1973 SYMP. ORE. STATE UNIV., CORVALLIS.
ANNO DESCRIBES THE EFFECTS OF FIRE, LOGGING AND HERBICIDES ON SMALL MAMMAL POPULATIONS IN MATURE DOUGLAS-FIR AND MIXED CONIFER

STANDS. SMALL MAMMALS RESPONDED TO HABITAT CHANGES CAUSED BY THESE DISTURBANCES ACCORDING TO THEIR HABITAT REQUIREMENTS.
KEYS SMALL MAMMALS, POST-FIRE SUCCESSION, SPECIES COMPOSITION, MORTALITY, SLASH FIRE, LOGGING, HABITAT, DEER MOUSE, SHREWS, VOLES, CHIPMUNKS, OREGON, DOUGLAS-FIR, HERBICIDE, POCKET GOPHERS, WILDFIRE, CLEARCUT, 1

27 AUTH BLACK H. C., TABER R. D.
DATE 1977.
TITL MAMMALS IN WESTERN CONIFEROUS FOREST ECOSYSTEMS: AN ANNOTATED BIBLIOGRAPHY.
PUBL BULL. NO. 2. CONIFEROUS FOREST BIOME ECOSYSTEM ANALYSIS STUDIES. US/INTERNATIONAL BIOLOGICAL PROGRAM. 199P.
ANNO ANNOTATED AND KEYWORDED BIBLIOGRAPHY OF MAMMALS IN WESTERN CONIFEROUS FORESTS.
KEYS SMALL MAMMALS, LARGE MAMMALS, PREDATORS, CONIFEROUS FOREST, BIBLIOGRAPHY, 1

28 AUTH BOCK J. H., BOCK C. E.
DATE 1978.
TITL RESPONSE OF BIRDS, SMALL MAMMALS, AND VEGETATION TO BURNING SACATON GRASSLANDS IN SOUTHEASTERN ARIZONA.
PUBL J. RANGE MANAGE. 31(4):295-300.
ANNO NUMBERS OF PEROMYSCUS WERE UNAFFECTED BY FIRE. COTTON RAT NUMBERS WERE REDUCED, BUT POCKET MICE AND KANGAROO RATS INCREASED. RELATED THESE CHANGES TO FOOD HABITS. SEED EATERS INCREASED, VEGETATION EATERS DECREASED.
KEYS SMALL MAMMALS, BIRDS, GRASSLAND, PRESCRIBED FIRE, ARIZONA, GRAZING, FOOD HABITS, RAPTORS, COTTON RAT, POCKET MOUSE, KANGAROO RATS, DEER MOUSE, 2

29 AUTH BOCK J. H., BOCK C. E., MCKNIGHT J. R.
DATE 1976.
TITL A STUDY OF THE EFFECTS OF GRASSLAND FIRES AT THE RESEARCH RANCH IN SOUTHEASTERN ARIZONA.
PUBL ARIZONA ACADEMY OF SCIENCE 11(3):49-57.
ANNO SMALL MAMMALS SHOWED NO SIGNIFICANT INCREASE IN BURNED AREA AND IN SOME CASES DECREASED.
KEYS WILDFIRE, BIRDS, SMALL MAMMALS, GRASSLAND, ARIZONA, 2

30 AUTH BORRECCO J. E., BLACK H. C., HOOVEN E. F.
DATE 1979.
TITL RESPONSE OF SMALL MAMMALS TO HERBICIDE-INDUCED HABITAT CHANGES.
PUBL NORTHWEST SCI. 53(2):97-106.
ANNO SPECIES COMPOSITION OF SMALL MAMMAL COMMUNITIES WAS ALTERED BY CONTROLLING THE HERBACEOUS VEGETATION. SPECIES PREFERRING GRASSY HABITATS- DEERMICE AND TROWBRIDGE SHREWS INCREASED AFTER TREATMENT WITH 2,4-D, VAGRANT SHREWS, OREGON VOLES AND PACIFIC JUMPING MICE DECREASED.
KEYS SMALL MAMMALS, HABITAT, HERBICIDE, CREEPING VOLE, DEER MOUSE, PACIFIC JUMPING MICE, TROWBRIDGE SHREW, VAGRANT SHREW, OREGON, 1

31 AUTH BRABANT A.
DATE 1922.
TITL THE FIRE FIEND'S THREAT TO THE FUR TRADE.
PUBL CAN. FOR. MAG. 18(12):1204-1205.
ANNO FIRE CAUSES DISAPPEARANCE OF MARTEN.
KEYS MARTEN, FIRE, PREDATORS

32 AUTH BRAND C. J., KEITH L. B.
DATE 1979.
TITL LYNX DEMOGRAPHY DURING A SNOWSHOE HARE DECLINE IN ALBERTA.
PUBL J. WILDL. MANAGE. 43(4):827-849.
ANNO DURING AN INTERVAL WHEN LYNX AND SNOWSHOE HARE POPULATIONS WERE DECLINING, THE BODY FAT OF LYNX DECLINED AND THE PERCENTAGE OF KITTENS IN THE POPULATION DECREASED.
KEYS PREDATORS, SMALL MAMMALS, LYNX, SNOWSHOE HARE, POPULATION DENSITY, ALBERTA,PREDATION, 1

33 AUTH BRAND C. J., KEITH L. B., FISCHER C. A.
DATE 1976.
TITL LYNX RESPONSES TO CHANGING SNOWSHOE HARE DENSITIES IN CENTRAL ALBERTA.
PUBL J. WILDL. MANAGE. 40:416-428.
ANNO WHEN THE POPULATION OF SNOWSHOE HARES WAS LOW, THERE WERE FEWER LYNX IN THE STUDY AREA AND THE FREQUENCY OF HARES IN THE LYNX DIET WAS LOWER THAN IN YEARS OF HARE ABUNDANCE.
KEYS LYNX, SNOWSHOE HARE, POPULATION DENSITY, PREDATORS, ALBERTA, SMALL MAMMALS, 3

34 AUTH BROADBROOKS H. E.
DATE 1970.
TITL POPULATIONS OF THE YELLOW-PINE CHIPMUNK, EUTAMIAS AMOENUS.
PUBL AM. MIDL. NAT. 83(2):472-488.
ANNO PINE SQUIRRELS, GOLDEN-MANTLED GROUND SQUIRRELS AND CHIPMUNKS, ALL DIURNAL AND SHARING HABITATS AND FOOD, LIVED TOGETHER SUCCESSFULLY. CHIPMUNK POPULATION DENSITY CONTROLLED BY SPACING OF INDIVIDUALS AND PREDATORS.
KEYS SMALL MAMMALS, YELLOW-PINE CHIPMUNK, PREDATORS, LYNX, HABITAT, FOOD HABITS, POPULATION DENSITY, PREDATION, WASHINGTON, RED SQUIRREL, GOLDEN-MANTLED GROUND SQUIRREL, SELECTIVE CUT, RAPTORS, REPTILES, 3

35 AUTH BUCKNER J. L., LANDERS J. L.
DATE 1979.
TITL FIRE AND DISKING EFFECTS ON HERBACEOUS FOOD PLANTS AND SEED SUPPLIES.
PUBL J. WILDL. MANAGE. 43(3):807-811.
ANNO ANNUALS AND MOST PERENIALS WERE FAVORED BY DISKING. SEEDS ON DISKED AND ANNUALLY BURNED SITES WERE AVAILABLE TO SEED EATERS. SEEDLINGS ON DOUBLE DISKED SITES DEVELOPED WITH LITTLE COMPETITION BECAUSE WIREGRASS AND BRACKEN FERN HAD BEEN ELIMINATED, AND SEED PRODUCTION INCREASED 34% OVER THAT IN ANNUALLY BURNED WOODS.
KEYS SMALL MAMMALS, LARGE MAMMALS, BIRDS, PRESCRIBED FIRE, DISKING, FOOD HABITS, SEED, 1, GEORGIA, LONGLEAF PINE-WIREGRASS-BRACKEN FERN,

36 AUTH BUECH R. R., SIDERITS K., RADTKE R. E., SHELDON H. L., ELSING D.
DATE 1977.
TITL SMALL MAMMAL POPULATIONS AFTER A WILDFIRE IN NORTHEAST MINNESOTA.
PUBL USDA FOR. SERV. RES. PAP. NC-151. 8P. NORTH CENTRAL FOR. EXP. STN., ST. PAUL, MINN.
ANNO AFTER A LARGE WILDFIRE ONLY 16 PERCENT AS MANY SMALL MAMMALS WERE IN THREE FOREST COMMUNITIES THAT HAD BURNED AS WERE IN COMPARABLE UNBURNED AREAS. THE RED-BACKED VOLE WAS THE MOST

AFFECTED. DEER MICE APPEARED TO HAVE IMMIGRATED INTO THE BURNED AREA.
KEYS RED-BACKED VOLES, DEER MOUSE, MASKED SHREW, ROCK VOLE, LEAST CHIPMUNK, POPULATION DENSITY, SPECIES DIVERSITY, MINNESOTA, SMALL MAMMALS, WILDFIRE, 1

37 AUTH BUECHNER H. K.
DATE 1942.
TITL INTERRELATIONSHIPS BETWEEN THE POCKET GOPHER AND LAND USE.
PUBL J. MAMMAL. 23(3):346-348.
ANNO OVERGRAZING GREATLY INCREASED THE NUMBER OF POCKET GOPHERS.
KEYS SMALL MAMMALS, POCKET GOPHERS, GRAZING, POPULATION DENSITY, GRASSLAND, TEXAS, 2

38 AUTH BURNS S.
DATE NO DATE.
TITL MANAGING SNAGS FOR WILDLIFE HABITAT. COORDINATING GUIDELINES FOR WILDLIFE HABITAT NO 2.
PUBL USDA FOR. SERV. BITTERROOT NATL. FOREST, NORTHERN REGION, MISSOULA, MONT.
ANNO RECOMMENDATIONS FOR PRESERVING SNAGS FOR WILDLIFE HABITAT.
KEYS SNAGS, BIRDS, SMALL MAMMALS, HABITAT, 3

39 AUTH BURTON D. H., BLACK H. C.
DATE 1978.
TITL FEEDING HABITS OF MAZAMA POCKET GOPHERS IN SOUTH-CENTRAL OREGON.
PUBL J. WILDL. MANAGE. 42(2):383-390.
ANNO MAZAMA POCKET GOPHERS PREFERRED SUCCULENT PLANTS. GRASSES WERE HEAVILY UTILIZED WHEN FORBS WERE NOT AVAILABLE. PONDEROSA PINE WERE EATEN IN THE WINTER, BUT WERE A VERY MINOR PART OF THE DIET. SUGGESTS HABITAT MODIFICATION TO CONTROL POCKET GOPHER DAMAGE TO TREE REGENERATION.
KEYS SMALL MAMMALS, WESTERN POCKET GOPHER, OREGON, FOOD HABITS, 2

40 AUTH CHEW R. M., BUTTERWORTH B. B., GRECHMAN R.
DATE 1958.
TITL THE EFFECTS OF FIRE ON THE SMALL MAMMAL POPULATIONS OF THE CHAPARRAL.
PUBL J. MAMMAL. 40(2):253.
ANNO GIVES NUMBERS OF SMALL MAMMAL CARCASSES FOUND IN CANYON AFTER CHAPARRAL FIRE. APPARENT CAUSE OF DEATH WAS ASPHYXIATION OR HEAT PROSTRATION.
KEYS SMALL MAMMALS, MORTALITY, CHAPARRAL, CALIFORNIA, WILDFIRE, 2

41 AUTH CLARK T. W., CAMPBELL T. M.
DATE 1979.
TITL POPULATION ORGANIZATION AND REGULATORY MECHANISMS OF PINE MARTEN IN GRAND TETON NATIONAL PARK, WYOMING.
PUBL IN PROC. 1ST CONF. ON SCI. RES. IN THE NATL. PARKS. VOL. I P. 293-295. R. M. LINN ED. USDI NATL. PARK SERV. TRANS. AND PROC. SERIES NO. 5.
ANNO STUDY ON UNDISTURBED MARTEN POPULATION IN GRAND TETON NATIONAL PARK AND AN ECOLOGICALLY SIMILILAR AREA ON THE TETON NATIONAL FOREST THAT WAS SUBJECT TO LOGGING. NO CHANGES IN TRAP UTILIZATION OR MARTEN HOME RANGES WERE OBSERVED AS A RESULT OF THE LOGGING OPERATIONS.
KEYS PREDATORS, MARTEN, GRAND TETON NATL. PARK, PREDATION, WYOMING, RODENTS, LOGGING, 1, POPULATION DENSITY, VEGETATION STRUCTURE

42 AUTH CLEARY B. D., GREAVES R. D., HERMANN R. K.
DATE 1978.
TITL REGENERATING OREGON'S FORESTS.
PUBL OREGON STATE UNIV. EXTENSION SERVICE, CORVALLIS, ORE. 203P.
ANNO SECTION ON DESTRUCTIVE IMPACTS OF MAMMALS ON REFORESTATION.
KEYS SMALL MAMMALS, LARGE MAMMALS, DAMAGE, 3, OREGON

43 AUTH CLOTHIER R. R.
DATE 1955.
TITL CONTRIBUTION TO THE LIFE HISTORY OF VAGRANT SHREW.
PUBL J. MAMMAL. 36(2):214-221.
ANNO LIFE HISTORY OF VAGRANT SHREW. THEY ARE MOST COMMON IN DAMP SITUATIONS, NEAR WATER. FOOD WAS MAINLY INSECTS, EARTHWORMS, AND OTHER SMALL INVERTEBRATES.
KEYS SMALL MAMMALS, VAGRANT SHREW, FOOD HABITS, HABITAT, MONTANA, 3

44 AUTH COOK S. F. JR.
DATE 1959.
TITL THE EFFECTS OF FIRE ON A POPULATION OF SMALL RODENTS.
PUBL ECOLOGY 40:102-108.
ANNO THE REDUCTION OF COVER RESULTING FROM FIRE WAS CONSIDERED TO BE THE MAJOR FACTOR LIMITING THE RECOVERY OF MICE. IN THE SECOND YEAR AFTER FIRE, THE INCREASE OF SEED PRODUCING ANNUALS FAVORED SEED EATING MICE.
KEYS SMALL MAMMALS, POPULATION DENSITY, GRASSLAND, BRUSH-GRASS, CALIFORNIA, WILDFIRE, 2, HABITAT, FOOD HABITS

45 AUTH COSTA R., FFOLLIOTT P. F., PATTON D. R.
DATE 1976.
TITL COTTONTAIL RESPONSES TO FOREST MANAGEMENT IN SOUTHWESTERN PONDEROSA PINE.
PUBL USDA FOR. SERV. RES. NOTE-RM 330. 4P. ROCKY MT. FOR. AND RANGE EXP. STN., FT. COLLINS, COLO.
ANNO WHEN MANAGING PONDEROSA PINE FOR TIMBER PRODUCTION USING SHELTERWOOD OR GROUP SELECTION, COTTONTAILS CAN BE INCREASED BY ENCOURAGING DENSE REGENERATION. IN CLEARCUTS, WINDROWING SLASH AND ENCOURAGING HERBACEOUS AND SHRUBBY GROWTH WILL INCREASE COTTONTAIL USE.
KEYS SMALL MAMMALS, COTTONTAIL RABBIT, CLEARCUT, PONDEROSA PINE, ARIZONA, LOGGING, 2, HABITAT

46 AUTH COWAN I. MCT., MACKAY R. H.
DATE 1950.
TITL FOOD HABITS OF THE MARTEN (MARTES AMERICANA) IN THE ROCKY MOUNTAIN REGION OF CANADA.
PUBL CAN. FIELD-NAT. 64(3):100-104.
ANNO MARTEN USED RED-BACKED VOLES MORE THAN ANY OTHER FOOD ITEM. SUGGESTS THAT VARYING HARE AND GROUSE '10YEAR' CYCLES DO NOT AFFECT MARTEN REPRODUCTION, BECAUSE THE MARTEN PREFERS A DIET OF VOLES.
KEYS MARTEN, FOOD HABITS, PREDATION, ALBERTA, POPULATION DENSITY, RED-BACKED VOLES, 2, PREDATORS, SMALL MAMMALS

47 AUTH COWLES R. B.
DATE 1967.
TITL FIRE SUPPRESSION, FAUNAL CHANGES AND CONDOR DIETS.
PUBL TALL TIMBERS FIRE ECOL. CONF. 7:217-244.
ANNO SUPPRESSION OF FIRE AND RESULTANT BRUSH FIELDS ON CALIFORNIA MOUNTAIN SIDES HAS CAUSED CALIFORNIA CONDORS TO SWITCH FROM A

PREFERRED DIET OF SMALL MAMMALS, ESPECIALLY RABBITS, TO CARCASSES OF LARGE HERBIVORES. SUGGESTS A CALCIUM DEFICIENCY HAS RESULTED FROM THE LACK OF SMALL BONES IN THE CONDORS' DIET.
KEYS RABBITS, CALIFORNIA, CALIFORNIA CONDOR, PREDATION, CHAPARRAL, CALIFORNIA, POST-FIRE SUCCESSION, SMALL MAMMALS, BIRDS, 3

48 AUTH CROUCH G. L.
DATE 1976.
TITL WILD ANIMAL DAMAGE TO FORESTS IN THE UNITED STATES AND CANADA.
PUBL IN XVI IUFRO WORLD CONGRESS PROC. DIV. II, NORWAY P. 468-478.
ANNO DESCRIBES DAMAGE TO FOREST TREES BY DIFFERENT KINDS OF WILDLIFE.
KEYS SMALL MAMMALS, LARGE MAMMALS, BIRDS, DAMAGE, U.S., CANADA, 3, RAPTORS

49 AUTH CROUCH G. L.
DATE 1979.
TITL ATRAZINE IMPROVES SURVIVAL AND GROWTH OF PONDEROSA PINE THREATENED BY VEGETATIVE COMPETITION AND POCKET GOPHERS.
PUBL FOR. SCI. 25(1):99-111.
ANNO ATRAZINE WAS SUCCESSFULLY USED TO REDUCE COMPETITIVE PLANT COVER AND POCKET GOPHER FOOD SUPPLY. FALL APPLICATIONS WERE MORE SUCCESSFUL THAN SPRING APPLICATIONS.
KEYS SMALL MAMMALS, POCKET GOPHERS, FOOD HABITS, PONDEROSA PINE, OREGON, HERBICIDE, 3

50 AUTH DAVIS P. R.
DATE 1976.
TITL RESPONSE OF VERTEBRATE FAUNA TO FOREST FIRE AND CLEARCUTTING IN SOUTH CENTRAL WYOMING.
PUBL USDA FOR. SERV. AND UNIV. OF WYOMING COOP AGREEMENTS NOS. 16-391-CA AND 16-464-CA. 94P.
ANNO COMPARED EFFECTS OF CLEARCUTS AND WILDFIRE ON WILDLIFE. REASONS FOR DIFFERENCES WERE DETERMINED. RECOMMENDATIONS WERE MADE TO MAKE CLEARCUTS MORE CLOSELY RESEMBLE FIRE. CLEARCUTS SUPPORTED MORE SMALL MAMMALS THAN FORESTED AREAS OR BURNS. IT WAS RECOMMENDED THAT SOME LOGGING RESIDUE BE LEFT FOR SMALL MAMMAL ESCAPE COVER. LEAST CHIPMUNKS AND GOLDEN-MANTLED GROUND SQUIRELS WERE MORE NUMEROUS IN BURNED THAN CLEARCUT AREAS, DEER MICE WERE MORE ABUNDANT IN BURNED AND CLEARCUT AREAS THAN FORESTED AREAS, AND RED-BACKED VOLES WERE MOST ABUNDANT IN FORESTED AREAS.
KEYS LARGE MAMMALS, SMALL MAMMALS, BIRDS, WILDFIRE, CLEARCUT, WYOMING, LODGEPOLE PINE, LEAST CHIPMUNK, GOLDEN-MANTLED GROUND SQUIRREL, DEER MOUSE, RED-BACKED VOLES, BIBLIOGRAPHY

51 AUTH DE VOS A.
DATE 1951.
TITL OVERFLOW AND DISPERSAL OF MARTEN AND FISHER FROM WILDLIFE REFUGES.
PUBL J. WILDL. MANAGE. 15(2):164-175.
ANNO POINTS OUT THE VALUE OF WILDLIFE REFUGES FOR PROTECTION AND AS CENTERS OF DISPERSAL FOR FUR-BEARERS.
KEYS PREDATORS, MARTEN, FISHER, POPULATION DENSITY, MIGRATION, 3

52 AUTH DE VOS A.
DATE 1951.
TITL RECENT FINDINGS IN FISHER AND MARTEN ECOLOGY AND MANAGEMENT.
PUBL TRANS. N. AM. WILDL. CONF. 16:498-507.

ANNO FISHER APPEAR TO ADAPT BETTER TO EARLIER SUCCESSIONAL STAGES THAN MARTEN, BUT BOTH ARE RARE IN RECENTLY LOGGED OR BURNED-OVER AREAS. FISHER FOOD FOR THE WINTER CONSISTED OF SNOWSHOE HARE, PORCUPINE, FISH, AND MICE.
KEYS PREDATORS, MARTEN, FISHER, SMALL MAMMALS, LOGGING, FIRE, 2, SNOWSHOE HARE, MICE, PORCUPINE

53 AUTH DEBYLE N. V.
DATE 1981.
TITL CLEARCUTTING AND FIRE IN THE LARCH-FIR FORESTS OF WESTERN MONTANA--A MULTIFACETED RESEARCH SUMMARY.
PUBL USDA FOR. SERV., GEN. TECH. REP. INT-99. INTERMT. FOREST AND RANGE EXP. STN., OGDEN, UTAH.
ANNO DISCUSSES EFFECT OF BROADCAST BURNING ON SMALL MAMMALS AND THE IMPLICATIONS FOR TREE REGENERATION.
KEYS SMALL MAMMALS, FOOD HABITS, CLEARCUT, POPULATION DENSITY, BROADCAST FIRE, 3

54 AUTH DICE L. R.
DATE 1925.
TITL A SURVEY OF THE MAMMALS OF CHARLEVOIX COUNTY, MICHIGAN, AND VICINITY.
PUBL UNIV. OF MICH. MUS. ZOOL., OCCAS. PAP. 159:1-33.
ANNO FIRE HAS DISASTEROUS EFFECT ON SMALL MAMMALS BECAUSE OF THE DESTRUCTION OF THEIR HABITAT AND FOOD. MARTEN AND FISHER WHICH ARE DEPENDANT ON SMALL MAMMALS FOR FOOD ARE ALSO ELIMINATED BY FIRE.
KEYS SMALL MAMMALS, MICHIGAN, LOGGING, FIRE, PREDATORS, MARTEN, FISHER, 2

55 AUTH DIMOCK E. J. II.
DATE 1974.
TITL ANIMAL POPULATIONS AND DAMAGE.
PUBL IN ENVIORNMENTAL EFFECTS OF FOREST RESIDUES MANAGEMENT IN THE PACIFIC NORTHWEST. O. P. CRAMER, ED. P.O-1-O-27. USDA FOR. SERV. GEN. TECH. REP. PNW-24, PAC. NORTHWEST FOR. AND RANGE EXP. STN., PORTLAND, ORE.
ANNO MOST RESIDUE TREATMENTS FURTHER ENHANCE HABITATS ALREADY IMPROVED FOR PROBLEM ANIMALS BY TIMBER HARVESTING. TREATMENTS THAT MODIFY RESIDUES THE LEAST APPEAR MOST PROMISING FOR ATTAINING TIMBER, RANGE, AND WILDLIFE PRODUCTION GOALS WITH MINIMUM DAMAGE FROM ANIMALS.
KEYS SMALL MAMMALS, LOGGING, RESIDUE TREATMENTS, HABITAT, DAMAGE, LARGE MAMMALS, BIRDS, PRESCRIBED FIRE

56 AUTH EADIE W. R.
DATE 1953.
TITL RESPONSE OF MICROTUS TO VEGETATIVE COVER.
PUBL J. MAMMAL. 34:263-264.
ANNO MICROTUS AVOIDED AREAS OF SPARCE VEGETATION IN MEADOW HABITAT. SUGGESTS REDUCTION OF GROUND VEGETATION IN ORCHARDS WOULD MAKE THEM LESS HABITABLE FOR VOLES.
KEYS SMALL MAMMALS, MEADOW VOLE, VEGETATION STRUCTURE, POPULATION DENSITY, HABITAT, 1

57 AUTH EASTMAN J.
DATE 1976.
TITL LURE OF THE BURN.
PUBL NAT. WILDL. 14(5):10.

ANNO BRIEFLY DESCRIBES SEVERAL BENEFICIAL EFFECTS OF FIRE ON WILDLIFE.
KEYS LARGE MAMMALS, SMALL MAMMALS, BIRDS, CALIFORNIA CONDOR, MORTALITY, FOOD HABITS, HABITAT, WILDFIRE, 2

58 AUTH EDGERTON P. J., THOMAS J. W.
DATE 1977.
TITL IMPACTS OF SILVICULTURE ON WILDLIFE HABITATS IN THE BLUE MOUNTAINS.
PUBL IN INTEGRATION OF FOREST RESOURCE MANAGEMENT IN THE BLUE MOUNTAINS, J. HERBST, ED., P.61-63. MAR. 1977. LA GRANDE, ORE. 66P.
ANNO DISCUSSES METHODS OF MODIFYING WILDLIFE HABITAT THROUGH SILVICULTURAL TECHNIQUES. EMPHASIS ON STRUCTURE OF VEGETATION.
KEYS HABITAT, LOGGING, OREGON, BIRDS, VEGETATION STRUCTURE, 2

59 AUTH EDWARDS R. Y.
DATE 1954.
TITL FIRE AND THE DECLINE OF A MOUNTAIN CARIBOU HERD.
PUBL J. WILDL. MANAGE. 18(4):521-526.
ANNO DISCUSSES THE LONG TERM EFFECTS OF CATASTROPHIC FIRE ON WILDLIFE. CLIMAX FOREST SPECIES DECLINED, SPECIES FAVORED BY EARLY SUCCESSION AND THEIR PREDATORS INCREASED.
KEYS LARGE MAMMALS, PREDATORS, SMALL MAMMALS, CARIBOU, MOOSE, MULE DEER, MARTEN, MOUNTAIN LION, COYOTE, WOLVERINE, BEAVER, FOOD HABITS, POPULATION DENSITY, BRITISH COLUMBIA, LONG TERM FIRE EFFECTS, WILDFIRE, 1

60 AUTH ELLISON L.
DATE 1946.
TITL THE POCKET GOPHER IN RELATION TO SOIL EROSION ON MOUNTAIN RANGE.
PUBL ECOLOGY 27(2):101-114.
ANNO ALTHOUGH POCKET GOPHERS ARE RESPONSIBLE FOR DOWNHILL DISPLACEMENT OF SOIL, OVERGRAZING IS THE PRIMARY CAUSE OF EROSION. GOPHERS INCREASED IN HEAVILY GRAZED AREAS BECAUSE OF THE INCREASE OF DEEP ROOTED OR BULBOUS FORBS. THE GOPHERS ACTUALLY IMPROVE SOIL AERATION AND IMPROVE WATER INFILTRATION.
KEYS SMALL MAMMALS, POCKET GOPHERS, POPULATION DENSITY, SOIL EROSION, UTAH, 2, GRAZING

61 AUTH ELLISON L., ALDOUS C. M.
DATE 1952.
TITL INFLUENCE OF POCKET GOPHERS ON VEGETATION OF SUBALPINE GRASSLAND IN CENTRAL UTAH.
PUBL ECOLOGY 33(2):177-186.
ANNO RESULTS OF A 9 YEAR STUDY WHERE GOPHERS WERE REMOVED FROM HALF OF THE STUDY AREA INDICATED THAT POCKET GOPHERS IMPROVE SOIL AERATION AND PROBABLY CAUSE AN INCREASE IN VEGETATION INSPITE OF WHAT THEY CONSUME..
KEYS SMALL MAMMALS, POCKET GOPHERS, POPULATION DENSITY, UTAH, SOIL, GRASSLAND, HABITAT, FIRE, GRAZING, SOIL COMPACTION, 2

62 AUTH EVANS K. E., PROBASCO G. E.
DATE 1977.
TITL WILDLIFE OF THE PRAIRES AND PLAINS.
PUBL USDA FOR. SERV. GEN. TECH. REP. NC-29, 18P. NORTH CENT. FOR. EXP. STN. ST., PAUL, MINN.

ANNO DISCUSSION OF WILDLIFE RESOURCES AND HABITAT MANAGEMENT OF GRASSLANDS IN THE U.S.
KEYS SMALL MAMMALS, LARGE MAMMALS, PREDATORS, AMPHIBIANS, REPTILES, GRASSLAND, HABITAT, BIRDS, 3

63 AUTH FALA R. A.
DATE 1975.
TITL EFFECTS OF PRESCRIBED BURNING ON SMALL MAMMAL POPULATIONS IN A MIXED-OAK CLEARCUT.
PUBL J. FOR. 73(9):586-587.
ANNO PRESCRIBED BURNING IN A MIXED-OAK CLEARCUT IN PENNSYLVANIA RESULTED IN A REDUCTION OF HERBIVOROUS SPECIES (VOLES), HOWEVER INSECTIVOROUS AND SEED EATING DEER MICE BECAME ESTABLISHED WITHIN ONE MONTH. CONCLUDED FIRE WAS ADVANTAGEOUS FOR SITE PREPARATION WHEN TREES ARE TO BE PLANTED BECAUSE IT REDUCED HERBIVOROUS SMALL MAMMALS.
KEYS SMALL MAMMALS, DEER MOUSE, RED-BACKED VOLES, MEADOW VOLE, POPULATION DENSITY, POST-FIRE SUCCESSION, OAK, PENNSYLVANIA, FOOD HABITS, PRESCRIBED FIRE, CLEARCUT, 1

64 AUTH FISHER E. L., HURLEY J. F.
DATE 1978.
TITL FUELS, MANAGEMENT AND WILDLIFE.
PUBL USDA FOR. SERV. COORDINATION GUIDELINES FOR WILDLIFE HABITATS, NO. 10. 14P. CALIFORNIA, REGION.
ANNO DESCRIBES METHODS OF MANAGING FUELS TO IMPROVE WILDLIFE HABITAT.
KEYS SMALL MAMMALS, LARGE MAMMALS, BIRDS, FISH, PREDATORS, FUELS, HABITAT MANAGEMENT, SLASH, PRESCRIBED FIRE, 2

65 AUTH FISHER J. L., CROSS S. P.
DATE 1979.
TITL BATTERY-LIGHT TRACKING AS A TECHNIQUE FOR STUDYING SMALL NOCTURAL MAMMAL MOVEMENTS.
PUBL NORTHWEST SCI. 53(2):90-93.
ANNO DESCRIBES A TECHNIQUE FOR MONITORING SMALL MAMMAL MOVEMENTS AT NIGHT USING A BATTERY-LIGHT PACKET ATTACHED TO MOUSE.
KEYS SMALL MAMMALS, MOVEMENTS, 2, MICE

66 AUTH FITCH H. S.
DATE 1947.
TITL PREDATION BY OWLS IN THE SIERRA FOOTHILLS OF CALIFORNIA.
PUBL CONDOR 49:137-151.
ANNO ANALYSIS OF FOOD HABITS OF OWLS PREYING ON SMALL MAMMALS.
KEYS SMALL MAMMALS, RAPTORS, OWLS, CALIFORNIA, PREDATION, GREAT HORNED OWL, BARN OWL, POCKET GOPHERS, 3

67 AUTH FITCH H. S.
DATE 1954.
TITL SEASONAL ACCEPTANCE OF BAIT BY SMALL MAMMALS.
PUBL J. MAMMAL. 35:39-47.
ANNO SMALL MAMMAL POPULATIONS VARY IN THEIR SUSCEPTIBILITY TO TRAPPING DUE TO SEASONAL CHANGES IN FOOD AVAILABILITY, WEATHER CONDITIONS AND OTHER FACTORS.
KEYS SMALL MAMMALS, FOOD HABITS, POPULATION DENSITY, TRAPPING, 2

68 AUTH FOGEL R. D., TRAPPE J. M.
DATE 1978.
TITL FUNGUS CONSUMPTION (MYCOPHAGY) BY SMALL MAMMALS.
PUBL NORTHWEST SCI. 52:1-31.
ANNO A REVIEW OF THE LITERATURE ON SMALL MAMMAL FOOD HABITS, DISCUSSION OF THE FOOD VALUE OF FUNGI, AND THE SIGNIFICANCE OF THE INTERDEPENDANCE OF SMALL MAMMALS AND FUNGI TO THE FOREST ECOSYSTEM.
KEYS SMALL MAMMALS, FOOD HABITS, BIBLIOGRAPHY, FUNGI, 2

69 AUTH FOWELLS H. A., SCHUBERT G. H.
DATE 1951.
TITL RECENT DIRECT SEEDING TRIALS IN THE PINE REGION OF CALIFORNIA.
PUBL USDA FOR. SERV. RES. NOTE NO. 78, 9P. CALIF. FOREST AND RANGE EXP. STN.
ANNO BURNING DID NOT PROTECT SEED PLANTINGS FROM RODENTS. BROADCAST POISONING OFFERED ONLY TEMPORARY RODENT CONTROL.
KEYS SMALL MAMMALS, FIRE, FOOD HABITS, 2, POISONS

70 AUTH FOX J. F.
DATE 1978.
TITL FOREST FIRES AND THE SNOWSHOE HARE - CANADA LYNX CYCLE.
PUBL OECOLOGIA (BERL.) 31:349-374.
ANNO AUTHOR SUPPORTS HYPOTHESIS OF POST-FIRE SECONDARY SUCCESSION TO ACCOUNT FOR SNOWSHOE HARE - CANADA LYNX PELT CYCLES, USING INFORMATION FROM FUR TRAPPING, FIRE HISTORY, PLANT ECOLOGY AND ANIMAL PHYSIOLOGY.
KEYS SNOWSHOE HARE, LYNX, POST-FIRE SUCCESSION, POPULATION DENSITY, FOOD HABITS, SMALL MAMMALS, PREDATORS, WILDFIRE, 2, CANADA

71 AUTH FRENZEL R. W., STARKEY E. E., BLACK H. C.
DATE 1979.
TITL EFFECTS OF PRESCRIBED BURNING ON SMALL MAMMAL COMMUNITIES IN THE LAVA BEDS NATIONAL MONUMENT, CALIFORNIA
PUBL IN PROC. 1ST CONF. ON SCI. RES. IN THE NATL. PARKS VOL. II. P. 287-292, R. M. LINN ED. USDI NATL. PARK SERV. TRANS. AND PROC. NO. 5. 1979.
ANNO PRESCRIBED FIRE IN SAGEBRUSH-BUNCHGRASS AND IN CHEATGRASS DID NOT HAVE AN IMMEDIATE EFFECT ON THE MAJOR SMALL MAMMAL SPECIES.
KEYS SMALL MAMMALS, PRESCRIBED FIRE, LAVA BEDS NATIONAL MONUMENT, CALIFORNIA, SAGEBRUSH-GRASS, CHEATGRASS, DEER MOUSE, HEERMANN KANGAROO RAT, GREAT BASIN POCKET MOUSE, MONTANE VOLE, 2

72 AUTH FRIDAY G. P.
DATE 1978.
TITL VEGETATIVE STRUCTURE AND MAMMALIAN UTILIZATION ON A FOREST-FIELD TRANSITION AND ITS ADJACENT HABITATS.
PUBL PH.D. DISSERTATION. MICH. STATE UNIV., EAST LANSING. 74P.
KEYS SMALL MAMMALS, WHITE-FOOTED MOUSE, EASTERN CHIPMUNK, FOX SQUIRREL, RED SQUIRREL, VEGETATION STRUCTURE, HABITAT, FOREST-FIELD TRANSITION, 2

73 AUTH GARMAN E. H., ORR-EWING A. L.
DATE 1949.
TITL DIRECT-SEEDING EXPERIMENTS IN THE SOUTHERN COASTAL REGION OF BRITISH COLUMBIA.
PUBL BRIT. COL. FOR. SERV., TECH. PUBL. T 31.
ANNO RAPID INCREASE IN SMALL MAMMAL POPULATION 2 WEEKS AFTER SLASH FIRE.

KEYS SMALL MAMMALS, SEED, SLASH FIRE, BRITISH COLUMBIA, POPULATION DENSITY, 2

74 AUTH GASHWILER J. S.
DATE 1959.
TITL SMALL MAMMAL STUDY IN WEST-CENTRAL OREGON.
PUBL J. MAMMAL. 40:128-138.
ANNO SMALL MAMMAL POPULATIONS WERE STUDIED IN LOGGED AND BURNED DOUGLAS-FIR. DEER MICE INCREASED AFTER LOGGING. AFTER BURNING THEY INCREASED 2-3 TIMES ABOVE DENSITIES IN VIRGIN FOREST. RED-BACKED VOLES INCREASED AFTER LOGGING, BUT DISAPPEARED AFTER FIRE. CHIPMUNKS DECREASED AFTER LOGGING AND AFTER FIRE.
KEYS SMALL MAMMALS, DEER MOUSE, RED-BACKED VOLES, CHIPMUNKS, CLEARCUT, DOUGLAS-FIR, PACIFIC NORTHWEST, POPULATION DENSITY, MORTALITY, SLASH FIRE, 1

75 AUTH GASHWILER J. S.
DATE 1965.
TITL TREE SEED ABUNDANCE VS. DEER MOUSE POPULATIONS IN DOUGLAS-FIR CLEARCUTS.
PUBL PROC. SOC. AM. FOR., 1965:219-222.
ANNO SPRING POPULATIONS OF DEER MICE SEEM TO BE AFFECTED BY FACTORS OTHER THAN SEED ABUNDANCE. FALL POPULATIONS DID NOT RESPOND TO CURRENT SEED CROPS, BUT SHOWED A POSITIVE RESPONSE TO MODERATE OR GOOD SEED CROPS FROM THE PRECEEDING YEAR. SIZE OF SPRING POPULATION HAS VERY LITTLE INFLUENCE ON THE SIZE OF FALL POPULATIONS AND VICE VERSA.
KEYS SMALL MAMMALS, DEER MOUSE, FOOD HABITS, SEED, DOUGLAS-FIR, CLEARCUT, DAMAGE, PACIFIC NORTHWEST, 2

76 AUTH GASHWILER J. S.
DATE 1967.
TITL CONIFER SEED SURVIVAL IN A WESTERN OREGON CLEARCUT.
PUBL ECOLOGY 48(3):431-438.
ANNO SMALL MAMMALS AND BIRDS CAUSED 63% OF DOUGLAS-FIR SEED LOSS ON CLEARCUT, AND 16% OF WESTERN HEMLOCK SEED LOSS.
KEYS SMALL MAMMALS, BIRDS, CLEARCUT, OREGON, SEED, FOOD HABITS, DOUGLAS-FIR, 2

77 AUTH GASHWILER J. S.
DATE 1969.
TITL DEER MOUSE REPOPULATION OF A POISONED DOUGLAS-FIR CLEARCUT.
PUBL J. FOR. 67(7):494-497.
ANNO POISONED BAIT WAS EFFECTIVE FOR 38 DAYS. IMMIGRATION OCCURRED 15-19 DAYS LATER. IN 5 TO 7 MONTHS THE POPULATION WAS BACK TO PREVIOUS LEVELS.
KEYS SMALL MAMMALS, DEER MOUSE, POISONS, DOUGLAS-FIR, CLEARCUT, POPULATION DENSITY, MIGRATION, OREGON, 2

78 AUTH GASHWILER J. S.
DATE 1970.
TITL FURTHER STUDY OF CONIFER SURVIVAL IN A WESTERN OREGON CLEARCUT.
PUBL ECOLOGY 51(5):849-854.
ANNO BIRDS, CHIPMUNKS, SHREWS AND MICE ACCOUNT FOR A LARGE PERCENTAGE OF THE LOSS OF NATURALLY DISSEMINATED SEED ON A CLEAR CUT.
KEYS SMALL MAMMALS, OREGON, CLEARCUT, SEED, FOOD HABITS, DOUGLAS-FIR, WESTERN HEMLOCK, WESTERN RED-CEDAR, BIRDS, MICE, SHREWS, CHIPMUNKS, 1

79 AUTH GASHWILER J. S.
DATE 1970.
TITL PLANT AND ANIMAL CHANGES ON A CLEARCUT IN WEST-CENTRAL OREGON.
PUBL ECOLOGY 51(6):1018-1026.
ANNO PLANT AND MAMMAL CHANGES IN A VIRGIN FOREST AND A BURNED CLEARCUT WERE STUDIED FOR 10 YEARS. DESCRIBES CHANGES IN SMALL MAMMAL POPULATIONS.
KEYS SMALL MAMMALS, CLEARCUT, DOUGLAS-FIR, OREGON, SPECIES COMPOSITION, POPULATION DENSITY, POST-FIRE SUCCESSION, DEER MOUSE, TOWNSEND'S CHIPMUNK, CREEPING VOLE, SNOWSHOE HARE, SHREWS, ERMINE, RED-BACKED VOLES, FLYING SQUIRRELS, DOUGLAS' SQUIRRELS, CALIFORNIA GROUND SQUIRREL, MIGRATION, SLASH FIRE, 1

80 AUTH GASHWILER J. S., ROBINETTE W. L., MORRIS D. W.
DATE 1960.
TITL FOODS OF BOBCATS IN UTAH AND EASTERN NEVADA.
PUBL J. WILDL. MANAGE. 24(2):226-229.
ANNO REPORTS STOMACH CONTENT ANALYSIS OF BOBCATS KILLED BY HUNTERS. HARES AND RABBITS WERE THE CHIEF FOOD ITEM.
KEYS PREDATORS, SMALL MAMMALS, BOBCAT, NEVADA, UTAH, BLACK-TAILED JACK RABBIT, RABBITS, PORCUPINE, DEER MOUSE, 2

81 AUTH GETZ L. L.
DATE 1968.
TITL INFLUENCE OF WATER BALANCE AND MICROCLIMATE ON THE LOCAL DISTRIBUTION OF THE RED-BACKED VOLE AND WHITE-FOOTED DEER MOUSE.
PUBL ECOLOGY 49:276-286.
ANNO RESTRICTION OF RED-BACKED VOLE HABITAT AS COMPARED TO THAT OF THE WHITE-FOOTED MOUSE WAS RELATED TO THE AVAILABILITY OF WATER, RATHER THAN OTHER ASPECTS OF THE MICROCLIMATE.
KEYS SMALL MAMMALS, RED-BACKED VOLES, WHITE-FOOTED MOUSE, MICROCLIMATE, MOISTURE REQUIREMENTS, NEW ENGLAND, UPLAND WOODS, SWAMPS, 1

82 AUTH GIVENS L. S.
DATE 1962.
TITL USE OF FIRE ON SOUTHEASTERN WILDLIFE REFUGES.
PUBL TALL TIMBERS FIRE ECOL. CONF. 1:121-126.
ANNO BURNING AT LEAST EVERY OTHER YEAR IS NECESSARY IN COASTAL MARSHES TO MAINTAIN EARLY SUCCESSIONAL STAGES AND PREFERRED FOODS OF MUSKRATS, BLUE AND SNOW GEESE.
KEYS MUSKRAT, BLUE GOOSE, SNOW GOOSE, COASTAL MARSHES, SOUTHEAST, SMALL MAMMALS, BIRDS, PRESCRIBED FIRE, 3

83 AUTH GODFREY G. K.
DATE 1955.
TITL OBSERVATIONS ON THE NATURE OF THE DECLINE IN NUMBERS OF TWO MICROTUS POPULATIONS.
PUBL J. MAMMAL. 36(2):209-214.
ANNO EXAMINES POSSIBLE CAUSES OF POPULATION FLUCTUATIONS OF FIELD VOLES. FINDING NO ENVIORNMENTAL CAUSES, SUPPORTS HYPOTHESIS THAT IN THE YEAR OF THE POPULATION CRASH, OVER-WINTERING ANIMALS ARE ABNORMAL FROM BIRTH AS A RESULT OF INTRASPECIFIC STRIFE THE PREVIOUS BREEDING SEASON.
KEYS VOLES, POPULATION DENSITY, ENGLAND, 3

84 AUTH GRAHAM S. A.
DATE 1928.
TITL INFLUENCE OF SMALL MAMMALS AND OTHER FACTORS UPON THE LARCH SAWFLY SURVIVAL IN THE LAKE STATES.
PUBL J. ECON. ENTOMOL.
ANNO MICE ARE IMPORTANT IN THE DESTRUCTION OF LARCH SAWFLY PREPUPAE. WHERE MOUSE POPULATIONS ARE HIGH, DESTRUCTION OF SAWFLIES IS HIGH. VOLES ATE MORE SAWFLY PREPUPAE THAN THE INSECTIVOROUS SHREWS.
KEYS SMALL MAMMALS, FOOD HABITS, LARCH SAWFLY, TAMARACK, MICHIGAN, VOLES, SHREWS, 2

85 AUTH GRANGE W.
DATE 1965.
TITL FIRE AND TREE GROWTH RELATIONSHIPS TO SNOWSHOE RABBITS.
PUBL TALL TIMBERS FIRE ECOL. CONF. 4:111-123.
ANNO SNOWSHOE RABBIT POPULATION EXPLOSIONS OCCUR ONLY ON VERY EARLY SUCCESSIONAL FOREST STAGES, NOT LONG AFTER THE OCCURRENCE OF FIRE. ALMOST ALL PLANT SPECIES IMPORTANT TO SNOWSHOE RABBITS HAVE ADAPTATIONS TO FIRE.
KEYS SNOWSHOE HARE, POPULATION DENSITY, CONIFEROUS FOREST, WISCONSIN, MINNESOTA, ALBERTA, BRITISH COLUMBIA, ALASKA, SMALL MAMMALS, POST-FIRE SUCCESSION, WILDFIRE, 2

86 AUTH GULLION G. W.
DATE 1977.
TITL MAINTENANCE OF THE ASPEN ECOSYSTEM AS A PRIMARY WILDLIFE HABITAT.
PUBL PROC. INT. CONGR. GAME BIOL. 13:256-265.
ANNO PROTECTION FROM FIRE AND FROM HARVESTING HAVE CAUSED LOSS OF ASPEN HABITAT THROUGH DECADENCE. SOME SPECIES OF WILDLIFE ARE CLOSELY TIED TO THE ASPEN HABITAT. COMMERCIAL HARVEST CAN BE ADJUSTED ECONOMICALLY TO MEET THE NEEDS OF THESE SPECIES OF WILDLIFE.
KEYS ASPEN, HABITAT, FIRE, BIRDS, PREDATORS, LARGE MAMMALS, 2

87 AUTH GUNDERSON H. L.
DATE 1959.
TITL RED-BACKED VOLE HABITAT STUDIES IN CENTRAL MINNESOTA.
PUBL J. MAMMAL. 40(3):405-412.
ANNO AVAILABILITY OF FREE WATER AND THE PRESENCE OF STUMPS, ROTTING LOGS AND ROOT SYSTEMS IN LOOSE FOREST LITTER AND SPAGNUM ARE IMPORTANT FACTORS IN THE HABITAT OF RED-BACKED VOLES.
KEYS SMALL MAMMALS, RED-BACKED VOLES, MINNESOTA, HABITAT, WHITE CEDAR, 3

88 AUTH HALVORSON C. H.
DATE 1981.
TITL SMALL MAMMAL POPULATIONS.
PUBL IN CLEARCUTTING AND FIRE IN THE LARCH-FIR FORESTS OF WESTERN MONTANA -- A MULTIFACETED RESEARCH SUMMARY. N. V. DEBYLE. USDA FOR. SERV. GEN. TECH. REP. INT-99. INTERMT. FOR. AND RANGE EXP. STN., OGDEN, UTAH.
ANNO AFTER CLEARCUTTING AND BURNING: DEER MICE INCREASED, RED-BACKED VOLES DISAPPEARED, CHIPMUNKS WERE REDUCED, AND LONG-TAILED VOLES WERE CAUGHT FOR THE FIRST TIME.
KEYS SMALL MAMMALS, DEER MOUSE, RED-TAILED CHIPMUNK, RED-BACKED VOLES, VAGRANT SHREW, FOOD HABITS, VEGETATION STRUCTURE, POST-FIRE SUCCESSION, LARCH-FIR, MONTANA, CLEARCUT, POPULATION

DENSITY, REPRODUCTION, BROADCAST FIRE, 1

89 AUTH HAMILTON W. J. JR.
DATE 1930.
TITL FOOD OF THE SORICIDAE.
PUBL J. MAMMAL. 11:26-39.
ANNO INSECTS MAKE UP MORE THAN HALF THE DIET OF THE SHREWS EXAMINED.
KEYS SMALL MAMMALS, INSECTS, FOOD HABITS, SHREWS, MICE, BIRDS, 2, LOGGING

90 AUTH HAMILTON W. J. JR., COOK D. B.
DATE 1940.
TITL SMALL MAMMALS AND THE FOREST.
PUBL J. FOR. 38(6):468-473.
ANNO SMALL MAMMALS BENEFIT THE FOREST BY CONSUMING LARGE QUANTITIES OF INJURIOUS INSECTS, IMPROVING SOIL AERATION, AND PROVIDING FOOD FOR PREDATORY BIRDS AND MAMMALS. SUGGESTS MANAGEMENT PRACTICES TO INCREASE SMALL MAMMAL POPULATIONS.
KEYS SMALL MAMMALS, FOOD HABITS, INSECTS, HABITAT, SOIL AERATION, 1

91 AUTH HANDLEY C. O. JR.
DATE 1969.
TITL FIRE AND MAMMALS.
PUBL TALL TIMBERS FIRE ECOL. CONF. 9:151-159.
ANNO DISCUSSION OF ADAPTATIONS OF MAMMALS TO FIRE. EMPHASIS ON GRASSLAND HABITATS.
KEYS PIKA, SMALL MAMMALS, LARGE MAMMALS, GRASSLAND, BEHAVIORAL ADAPTATIONS, MORPHOLOGICAL ADAPTATIONS, WILDFIRE, 2

92 AUTH HANSEN L. P., WARNOCK J. E.
DATE 1978.
TITL RESPONSE OF TWO SPECIES OF PEROMYSCUS TO VEGETATIONAL SUCCESSION OF LAND STRIP-MINED FOR COAL.
PUBL AM. MIDL. NAT. 100(2):416-423.
KEYS SMALL MAMMALS, DEER MOUSE, WHITE-FOOTED MOUSE, PLANT SUCCESSION, STRIP-MINING, 2

93 AUTH HANSON E. E.
DATE 1977.
TITL RADIOTELEMETRY STUDIES OF ARCTIC FOXES IN PRUDHOE BAY, ALASKA.
PUBL ECOLOGY SECTION H-8 UNIV. OF CALIF. LOS ALAMOS SCIENTIFIC LAB. LOS ALAMOS, NEW MEXICO 87544.
ANNO REPORT ON THE ECOLOGY OF ARCTIC FOX IN PRUDHOE BAY. SOME INFORMATION ON THE EFFECT OF LEMMING POPULATIONS ON THE REPRODUCTION OF FOXES.
KEYS ARCTIC FOX,, BIRDS, PREDATION, POPULATION DENSITY, ALASKA, SMALL MAMMALS, 3, PREDATORS

94 AUTH HANSON E. E.
DATE 1978.
TITL THE IMPACT OF A PRESCRIBED BURN IN A TEMPERATE SUBALPINE FOREST UPON THE BREEDING BIRD AND SMALL MAMMAL POPULATIONS.
PUBL M.S. THESIS. CENTRAL WASHINGTON UNIV., ELLENSBURG, WA. 55P.
ANNO POPULATION DENSITIES OF SMALL MAMMALS DECLINED FOLLOWING BURNING EXCEPT FOR THE YELLOW PINE CHIPMUNK. THE DECLINE OF THE OTHER SPECIES WAS ATTRIBUTED TO THE LACK OF GROUND VEGETATION THE FIRST SUMMER FOLLOWING THE BURN. THE NUMBER OF BIRDS REMAINED THE SAME AFTER BURNING BUT THE SPECIES DIVERSITY INCREASED.

KEYS BIRDS, YELLOW-PINE CHIPMUNK, TOWNSEND'S CHIPMUNK, DOUGLAS' SQUIRREL, RED-BACKED VOLES, DEER MOUSE, SPECIES DIVERSITY, POPULATION DENSITY, HABITAT, MOSAIC, SMALL MAMMALS, PRESCRIBED FIRE, SUBALPINE FOREST, WASHINGTON, 2

95 AUTH HARRIS A. S.
DATE 1968.
TITL SMALL MAMMALS AND NATURAL REFORESTATION IN SOUTHEAST ALASKA.
PUBL USDA FOR. SERV. RES. NOTE PNW-75, 7P. PAC. NORTHWEST FOR. AND RANGE EXP. STN., PORTLAND, ORE.
ANNO CONTRARY TO THE USUAL SMALL MAMMAL POPULATION RESPONSES TO LOGGING, IN THIS STUDY PEROMYSCUS WERE SIX TIMES MORE PLENTIFUL IN THE TIMBER THAN IN THE CUTOVER PLOTS, WHEREAS MICROTUS WERE SIX TIMES, AND SOREX TWICE AS NUMEROUS ON THE CUT. DESPITE SMALL MAMMALS, ADEQUATE NATURAL REGENERATION OF SITKA SPRUCE AND WESTERN HEMLOCK OCCURRED.
KEYS SMALL MAMMALS, ALASKA, DEER MOUSE, VOLES, SHREWS, LOGGING, SITKA SPRUCE, WESTERN HEMLOCK, 2

96 AUTH HARTESVELDT R. J., HARVEY H. T.
DATE 1967.
TITL THE FIRE ECOLOGY OF SEQUOIA REGENERATION.
PUBL TALL TIMBERS FIRE ECOL. CONF. 7:65-77.
ANNO CHICKAREES HARVEST AND EAT THE FLESH OF THE SEQUOIA CONE SCALES. THE SEEDS ARE ONLY PARTIALLY CONSUMED. AFTER FIRES WHICH KILL MANY FIRS AND PINES, CHICKAREES RELY MORE ON SEQUOIA CONES AND POSSIBLY INCREASE THE DISPERSAL OF SEEDS AT A TIME WHEN SUBSTRATE CONDITIONS RESULTING FROM FIRE ARE OPTIMAL FOR REGENERATION.
KEYS DOUGLAS' SQUIRREL, SEQUOIA, FOOD HABITS, SMALL MAMMALS, WILDFIRE, 3

97 AUTH HARTESVELDT R. J., HARVEY H. T., SHELLHAMMER H. S., STECKER R. E.
DATE 1975.
TITL THE GIANT SEQUOIA OF THE SIERRA NEVADA.
PUBL USDI NATIONAL PARK SERVICE, WASHINGTON D.C. 180P.
ANNO DESCRIBES THE EFFECT OF THE CHICKAREE ON THE DISPERSAL OF SEQUOIA SEED.
KEYS SMALL MAMMALS, DOUGLAS' SQUIRREL, SEQUOIA, FOOD HABITS, 3

98 AUTH HAWLEY V. D., NEWBY F. E.
DATE 1957.
TITL MARTEN HOME RANGE AND POPULATION FLUCTUATIONS.
PUBL J. MAMMAL. 38(2):174-184.
ANNO HOME RANGES FOR 6 MALE MARTEN AVERAGED .92 SQ. MILES, AND .27 SQ. MILES FOR 5 FEMALES. POPULATION FLUCTUATIONS OF MARTEN RESPONDED TO THE NUMBERS OF SMALL MAMMALS.
KEYS MARTEN, POPULATION DENSITY, GLACIER NATIONAL PARK, PREDATORS, SMALL MAMMALS, 3, MONTANA

99 AUTH HAYWARD C. L.
DATE 1940.
TITL FEEDING HABITS OF THE RED SQUIRREL.
PUBL J. MAMMAL. 21(2):220.
ANNO RECORDS OF RED SQUIRREL CONE CUTTING ACTIVITY AND NUMBER OF DOUGLAS-FIR SEEDS CONSUMED AT ONE TIME.
KEYS RED SQUIRREL, SMALL MAMMALS, FOOD HABITS, DOUGLAS-FIR, SEED, UTAH, 3

100 AUTH HEALEY M. C.
DATE 1967.
TITL AGGRESSION AND SELF-REGULATION OF POPULATION SIZE IN DEER MICE.
PUBL ECOLOGY 48(3):377-391.
ANNO CHANGES IN GROWTH AND SURVIVAL OF YOUNG DEER MICE CORRELATED TO CHANGES IN THE AGGRESSIVENESS OF ADULT MICE.
KEYS SMALL MAMMALS, DEER MOUSE, POPULATION DENSITY, BRITISH COLUMBIA, REPRODUCTION, 3

101 AUTH HICKIE P.
DATE 1957.
TITL THE APPLICATION OF ECOLOGY TO WILDLIFE MANAGEMENT.
PUBL ECOLOGY 38(1):53-56.
ANNO RODENT POPULATIONS INCREASE IN WEEDY SHRUBBY HABITAT AFTER LOGGING. AERIAL SEEDING OF DOUGLAS-FIR REQUIRES RODENT CONTROL FOR SUCCESS. DESCRIBES METHODS OF POSSIBLE CONTROL.
KEYS SMALL MAMMALS, RODENTS, FOOD HABITS, SEED, DOUGLAS-FIR, POPULATION DENSITY, PACIFIC NORTHWEST, LOGGING, PLANT SUCCESSION, GRAZING, 2

102 AUTH HISAW F. L., GLOYD H. K.
DATE 1926.
TITL THE BULL SNAKE AS A NATURAL ENEMY OF INJURIOUS RODENTS.
PUBL J. MAMMAL. 7(3):200-205.
ANNO DESCRIPTION OF THE BULL SNAKE AS A PREDATOR OF POCKET GOPHER. DESCRIBES KILLING TECHNIQUE AND BURROWING HABITS OF THE SNAKE AS WELL AS THE POTENTIAL CONSUMPTION OF GOPHERS.
KEYS SMALL MAMMALS, REPTILES, PREDATION, BULL SNAKE, POCKET GOPHERS, 3

103 AUTH HOFFMAN G. R.
DATE 1960.
TITL THE SMALL MAMMAL COMPONENTS OF SIX CLIMAX PLANT ASSOCIATIONS IN EASTERN WASHINGTON AND NORTHERN IDAHO.
PUBL ECOLOGY 41(3):571-572.
ANNO AN EXTENSION OF RICKARD'S 1960 PAPER. IDENTIFIES ELEVEN SPECIES OF SMALL MAMMALS FROM 6 CLIMAX PLANT ASSOCIATIONS THAT HAD NOT BEEN STUDIED BY RICKARD. DESCRIBES HABITATS OF DIFFERENT SPECIES.
KEYS SMALL MAMMALS, IDAHO, WASHINGTON, HABITAT, CHIPMUNKS, RED-BACKED VOLES, SHREWS, DEER MOUSE, MEADOW VOLE, 3

104 AUTH HOFFMAN R. S., PATTIE D. L.
DATE 1968.
TITL A GUIDE TO MONTANA MAMMALS: IDENTIFICATION, HABITAT, DISTRIBUTION AND ABUNDANCE.
PUBL UNIVERSITY OF MONTANA PRINTING SERVICES, MISSOULA. 133P.
ANNO IDENTIFICATION KEY, HABITAT DESCRIPTION, AND DISTRIBUTION MAPS FOR MONTANA MAMMALS.
KEYS SMALL MAMMALS, PREDATORS, LARGE MAMMALS, IDENTIFICATION KEY, HABITAT, MONTANA

105 AUTH HOOVEN E. F.
DATE 1958.
TITL THE RELATIONSHIP OF THE WHITE-FOOTED DEER MOUSE TO REFORESTATION BY DIRECT SEEDING IN THE TILLAMOOK BURN.
PUBL M.S. THESIS, OREGON STATE UNIV., CORVALLIS. 72P.
ANNO THE WHITE-FOOTED DEER MOUSE EATS AND STORES LARGE QUANTITIES OF CONIFER SEEDS, WHICH PRESENTS A PROBLEM TO REFORESTATION.

SUCCESS OF CONTROL PROGRAM DEPENDS ON KNOWLEDGE OF LIFE HISTORY FOR BEST TIME TO ATTEMPT CONTROL.
KEYS SMALL MAMMALS, DEER MOUSE, SEED, FOOD HABITS, OREGON, 3

106 AUTH HOOVEN E. F.
DATE 1969.
TITL THE INFLUENCE OF FOREST SUCCESSION ON POPULATIONS OF SMALL MAMMALS IN WESTERN OREGON.
PUBL IN WILDLIFE AND REFORESTATION IN THE PACIFIC NORTHWEST. P. 30-34. H. C. BLACK, ED. SCHOOL OF FORESTRY, ORE. STATE UNIV., CORVALLIS.
ANNO REVIEW OF EFFECTS OF FIRE, LOGGING AND OTHER DISTURBANCE ON SMALL ANIMALS. IN OREGON STUDY AREAS, SMALL MAMMALS MORE ABUNDANT IN RECENTLY LOGGED AREA THAN IN MATURE DOUGLAS-FIR. SUCCESSION OF SMALL MAMMAL AND BIRD SPECIES RELATED TO PLANT SUCCESSION AFTER LOGGING AND FIRE.
KEYS SMALL MAMMALS, LOGGING, WILDFIRE, OREGON, DOUGLAS-FIR, BIRDS, DEER MOUSE, POST-FIRE SUCCESSION, POPULATION DENSITY, SPECIES COMPOSITION, HABITAT, FOOD HABITS, REPRODUCTION, PRESCRIBED FIRE, 1

107 AUTH HOOVEN E. F.
DATE 1971.
TITL POCKET GOPHER DAMAGE ON PONDEROSA PINE PLANTATIONS IN SOUTHWESTERN OREGON.
PUBL J. WILDL. MANAGE. 35(2):346-353.
ANNO PONDEROSA SEEDLING SURVIVAL WAS REDUCED TO 12% IN AREAS OCCUPIED BY POCKET GOPHERS. CONTROL OF POCKET GOPHERS IS GENERALLY UNSUCCESSFUL. SUGGESTS CONTROLLING GOPHER POPULATIONS BY MODIFYING THE HABITAT I.E. CHANGING THE VEGETATION OR OTHER IMPORTANT PHYSICAL REQUIREMENTS.
KEYS SMALL MAMMALS, POCKET GOPHERS, PONDEROSA PINE, OREGON, SEED, FOOD HABITS, LOGGING, POPULATION DENSITY, 1, DAMAGE

108 AUTH HOOVEN E. F.
DATE 1973.
TITL EFFECTS OF VEGETATIONAL CHANGES ON SMALL FOREST MAMMALS.
PUBL IN EVEN-AGE MANAGEMENT SYMPOSIUM P.75-97, R. K. HERMANN AND D. P. LAVENDER, EDS., OREGON STATE UNIV, CORVALLIS. 249P.
ANNO LITERATURE REVIEW OF THE EFFECTS OF VEGETATIONAL CHANGES ON SMALL MAMMALS. CONCLUDES THAT REGARDLESS OF FOREST TREATMENT, THE SMALL MAMMAL BIOMASS REMAINS COMPARABLE TO THAT IN THE UNCUT FOREST AND EXERTS THE SAME PRESSURE ON REGENERATION.
KEYS SMALL MAMMALS, CLEARCUT, FIRE, LOGGING, POST-FIRE SUCCESSION, SEED, FOOD HABITS, SPECIES COMPOSITION, POPULATION DENSITY, 2

109 AUTH HOOVEN E. F.
DATE 1973.
TITL RESPONSE OF THE OREGON CREEPING VOLE TO THE CLEARCUTTING OF A DOUGLAS FIR FOREST.
PUBL NORTHWEST SCI. 47(4):256-264.
ANNO THREE YEAR STUDY OF EFFECT OF CLEARCUTTING AND BURNING ON CREEPING VOLE. VOLES INCREASED RAPIDLY WHEN TIMBER WAS REMOVED. INCREASED HERBACEOUS GROWTH AND RELEASED NUTRIENTS MAY IMPROVE HABITAT FOR VOLES.
KEYS CREEPING VOLE, SMALL MAMMALS, DOUGLAS-FIR, OREGON, CLEARCUT, HABITAT, POST-FIRE SUCCESSION, REPRODUCTION, POPULATION DENSITY, SLASH FIRE, 2

110 AUTH HOOVEN E. F.
DATE 1973.
TITL A WILDLIFE BRIEF FOR THE CLEARCUT LOGGING OF DOUGLAS-FIR.
PUBL J. FOR. 71(4):210-214.
ANNO STAGGERED CLEARCUT LOGGING OF 30 TO 60 ACRES IS BENEFICIAL TO WILDLIFE IN NORTHWESTERN OREGON. SMALL MAMMAL POPULATIONS INCREASE AS THE VEGETATION INCREASES AND ASSOCIATED ANTHROPOD POPULATIONS INCREASE. DESCRIBES SUCCESSIONAL STAGES PREFERRED BY DIFFERENT SMALL MAMMALS.
KEYS CLEARCUT, DOUGLAS-FIR, LARGE MAMMALS, SMALL MAMMALS, FISH, SOIL CHARACTERISTICS, OREGON, REPTILES, BIRDS, PLANT SUCCESSION, 1

111 AUTH HOOVEN E. F.
DATE 1975.
TITL BAITING TO REDUCE LOSSES OF CONIFER SEEDS TO SMALL FOREST MAMMALS.
PUBL RES. NOTE NO. 55. SCHOOL OF FOR., ORE. STATE UNIV. AND FOR. RES. LAB., CORVALLIS.
ANNO A CAGED DEER MOUSE CAN EAT 250-350 DOUGLAS-FIR SEEDS PER DAY. DESCRIBES THE EFFECTIVENESS OF DIFFERENT RODENTICIDES TO CONTROL SMALL MAMMALS WHICH EAT CONIFER SEEDS.
KEYS SMALL MAMMALS, FOOD HABITS, POISONS, POPULATION DENSITY, OREGON

112 AUTH HOOVEN E. F., BLACK H. C., LOWRIE J. C.
DATE 1979.
TITL DISTURBANCE OF SMALL MAMMAL LIVE TRAPS BY SPOTTED SKUNKS.
PUBL NORTHWEST SCI. 53(2):79-81.
ANNO SKUNKS WERE CONSIDERED RESPONSIBLE FOR DISTURBING SMALL MAMMAL TRAPS AND EATING TRAPPED MICE.
KEYS SMALL MAMMALS, SKUNK, PREDATORS, SLASH FIRE, TRAPPING, OREGON, LOGGING, DEER MOUSE, SHREWS, TOWNSEND'S CHIPMUNK, CREEPING VOLE, 2

113 AUTH HORN E. E.
DATE 1938.
TITL SOME WILDLIFE-FOREST RELATIONSHIPS.
PUBL TRANS. N. AM. WILDL. CONF. 3:376-380.
ANNO DISCUSSES THE EFFECTS OF FIRE AND LOGGING ON WILDLIFE IN TERMS OF COVER, FOOD, AND PREDATION.
KEYS SMALL MAMMALS, FOOD HABITS, VEGETATION STRUCTURE, LARGE MAMMALS, LOGGING, PREDATION, HABITAT, MORTALITY, PRESCRIBED FIRE, 2

114 AUTH HORTON J.
DATE 1930.
TITL BIRDS AND ANIMALS KILLED BY FOREST FIRES.
PUBL MURRELET 11(2):22.
KEYS MAMMALS, BIRDS, WILDFIRE, MORTALITY, 2

115 AUTH HOUTCOOPER W. C.
DATE 1978.
TITL FOOD HABITS OF RODENTS IN A CULTIVATED ECOSYSTEM.
PUBL J. MAMMAL. 59(2):427-430.
ANNO RODENTS UTILIZED PLANT MATERIAL FOR FOOD IN WINTER, ANIMAL MATERIAL (INSECTS) UTILIZED IN SUMMER.
KEYS SMALL MAMMALS, HOUSE MOUSE, DEER MOUSE, FOOD HABITS, INDIANA, CORN , 3

116 AUTH HOWARD W. E., FENNER R. L., CHILDS H. E. JR.
DATE 1959.
TITL WILDLIFE SURVIVAL ON BRUSH BURNS.
PUBL J. RANGE MANAGE. 12:230-234.
ANNO MOST VERTEBRATES ARE NOT KILLED BY FIRE. CHANGES IN POPULATION DENSITIES AFTER FIRE ARE IN RESPONSE TO ALTERATIONS OF HABITAT. DATA TAKEN FROM ANIMALS IN CAGES WITH TEMPERATURE RECORDING DEVICES AND OBSERVATIONS OF WILD ANIMALS BEFORE, DURING AND AFTER THE FIRE.
KEYS SMALL MAMMALS, REPTILES, MORTALITY, BRUSH-GRASS, CALIFORNIA, BIRDS, PRESCRIBED FIRE, 1

117 AUTH INGRAM R.
DATE 1973.
TITL WOLVERINE, FISHER, AND MARTEN IN CENTRAL OREGON.
PUBL OREGON STATE GAME COMM. CENTRAL REGION ADM. REP. 73-2. 39P.
ANNO LOGGING AND FIRE HAVE A NEGATIVE EFFECT ON FISHER AND MARTEN POPULATIONS. WOLVERINE HAVE BEEN LESS EFFECTED BECAUSE OF THE REMOTENESS OF THEIR HABITAT. HUMAN ACTIVITY WILL LIMIT WOLVERINE POPULATIONS. DISCUSSION OF HABITAT, FOOD HABITS AND REPRODUCTION.
KEYS WOLVERINE, FISHER, MARTEN, OREGON, PREDATORS, PREDATION, SMALL MAMMALS, HABITAT, LOGGING, FIRE, CONIFEROUS FOREST, POPULATION DENSITY, 3

118 AUTH JAMESON E. W. JR.
DATE 1955.
TITL SOME FACTORS AFFECTING FLUCTUATIONS OF MICROTUS AND PEROMYSCUS.
PUBL J. MAMMAL. 36(2):206-209.
ANNO DISCUSSES THE DIFFERENCES IN POPULATION FLUCTUATIONS OF PEROMYSCUS AND MICROTUS AND THEIR RELATIONSHIP TO FACTORS SUCH AS FOOD QUALITY, FOOD QUANTITY, HABITAT, AND STRESS.
KEYS SMALL MAMMALS, VOLES, DEER MOUSE, POPULATION DENSITY, FOOD HABITS,2

119 AUTH JOHNSON D. R., HANSEN R. M.
DATE 1969.
TITL EFFECTS OF RANGE TREATMENT WITH 2,4-D ON RODENT POPULATIONS.
PUBL J. WILDL. MANAGE. 33(1):125-132.
ANNO TREATMENT WITH 2,4-D RESULTED IN AN INCREASE IN GRASS COVER AND A DECREASE IN FORBS AND BRUSH. DISCUSSES EFFECT ON POPULATION DENSITY AND LITTER SIZE OF VARIOUS RODENTS. 2,4-D CAUSED A REDUCTION OF GOPHERS AND CHIPMUNKS, WHILE VOLES INCREASED. GOPHERS RESPONDED PRIMARILY TO CHANGES IN FOOD, CHIPMUNKS TO FOOD AND COVER, AND VOLES TO COVER.
KEYS SMALL MAMMALS, POPULATION DENSITY, HERBICIDE, COLORADO, BRUSH-GRASS, DEER MOUSE, POCKET GOPHERS, MONTANE VOLE, LEAST CHIPMUNK, FOOD HABITS, VEGETATION STRUCTURE, 1

120 AUTH JOHNSON M.K., HANSEN R. M.
DATE 1979.
TITL COYOTE FOOD HABITS ON THE IDAHO NATIONAL ENGINEERING LABORATORY.
PUBL J. WILDL. MANAGE. 43(4):951-956.
ANNO COYOTES SELECT AN ABUNDANT FOOD AND MAKE IT A STAPLE AND THEREFORE ARE SELECTIVE RATHER THAN OPPORTUNISTIC PREDATORS.
KEYS PREDATORS, COYOTE, FOOD HABITS, IDAHO, SAGEBRUSH, SMALL MAMMALS, PREDATION, RABBITS, 1

121 AUTH JONES J. H., SMITH N. S.
DATE 1979.
TITL BOBCAT DENSITY AND PREY SELECTION IN CENTRAL ARIZONA.
PUBL J. WILDL. MANAGE. 43(3):666-672.
ANNO ANALYSIS OF BOBCAT SCATS FROM THREE BAR WILDLIFE AREA INDICATED THAT RODENTS (67%), AND LAGOMORPHS (38%), WERE THE MOST COMMON FOOD ITEMS. POPULATION DENSITIES OF RODENTS AND LAGOMORPHS WERE NOT RELATED TO THE SELECTION OF PREY BY BOBCATS.
KEYS PREDATORS, BOBCAT, PREDATION, ARIZONA, SMALL MAMMALS, DESERT COTTONTAIL, KANGAROO RATS, POCKET MOUSE, WOODRATS, BLACK-TAILED JACK RABBIT, 1

122 AUTH KEITH L. B., SURRENDI P. C.
DATE 1971.
TITL EFFECTS OF FIRE ON A SNOWSHOE HARE POPULATION.
PUBL J. WILDL. MANAGE. 35(1):16-26.
ANNO SNOWSHOE HARES MOVED FROM SEVERELY BURNED SITES TO SURROUNDING HABITAT, RETURNING THE SECOND SUMMER AFTER THE FIRE AS BRUSH COVER SPROUTED. THERE WAS NO EVIDENCE OF HARES KILLED BY THE FIRE.
KEYS SMALL MAMMALS, SNOWSHOE HARE, MORTALITY, MIGRATION, POPULATION DENSITY, REPRODUCTION, ALBERTA, WILDFIRE, 2

123 AUTH KEITH L. B., TODD A. W., BRAND C. J., ADAMCIK R. S., RUSH D. H.
DATE 1977.
TITL AN ANALYSIS OF PREDATION DURING A CYCLIC FLUCTUATION OF SNOWSHOE HARES.
PUBL PROC. INT. CONGR. GAME BIOL. 13:151-175.
ANNO DESCRIPTION OF LYNX, COYOTE, AND RAPTOR, POPULATION RESPONSES TO FLUCTUATIONS IN HARE AND GROUSE DENSITIES. SUGGESTS THE 10-YEAR CYCLE IS GENERATED INTRINSICALLY BY SUCCESSIVE HARE-VEGETATION AND HARE-PREDATOR CYCLES.
KEYS SMALL MAMMALS, PREDATORS, RAPTORS, SNOWSHOE HARE, LYNX, COYOTE, GREAT HORNED OWL, GOSHAWK, RED-TAILED HAWK, BIRDS, RUFFED GROUSE, POPULATION DENSITY, LYNX, 2

124 AUTH KIPP D. H.
DATE 1941.
TITL WILDLIFE IN A FIRE.
PUBL AM. FOR. 37(6):323-325.
ANNO DESCRIBES DIRECT EFFECTS OF WILDFIRE ON WILDLIFE.
KEYS WILDFIRE, MORTALITY, WISCONSIN, BIRDS, LARGE MAMMALS, SMALL MAMMALS, RABBITS, RAPTORS, FISH, FALL BURN, BIRDS, 2

125 AUTH KIRKLAND G. L. JR.
DATE 1977.
TITL RESPONSES OF SMALL MAMMALS TO THE CLEARCUTTING OF NORTHERN APPALACHIAN FORESTS.
PUBL J. MAMMAL. 58(4):600-609.
ANNO CLEARCUTTING IN BOTH NORTHERN DECIDUOUS AND BOREAL CONIFEROUS FORESTS RESULTED IN INCREASED SMALL MAMMAL ABUNDANCE AND DIVERSTY WHICH PERSISTED UNTIL SUCCESSION RETURNED THE AREA TO FOREST.
KEYS SMALL MAMMALS, CLEARCUT, SPECIES DIVERSITY, POPULATION DENSITY, WEST VIRGINIA, PLANT SUCCESSION, 2

126 AUTH KIRKPATRICK R. C.
DATE 1941.
TITL EFFECTS OF FIRES ON WILDLIFE.
PUBL WIS. CONSERV. BULL. 6(5):28-30.
KEYS SMALL MAMMALS, FIRE

127 AUTH KLEBENOW D. R., BEALL R., BRUNER A., MASON R., ROUNDY B., STAGER W., WARD K.
DATE 1976.
TITL CONTROLLED FIRE AS A MANAGEMENT TOOL IN THE PINYON-JUNIPER WOODLAND, NEVADA
PUBL ANN. PROG. REP. COOP. RES. USDA AND NEV. AGRIC. STN.
ANNO CONTROLLED BURNING INCREASED NUMBERS OF RODENTS AND BIRDS. SPECIES DIVERSITY INCREASED FOR BIRDS, BUT DECREASED FOR RODENTS.
KEYS PRESCRIBED FIRE, SMALL MAMMALS, BIRDS, NEVADA, PINYON-JUNIPER, POPULATION DENSITY, SPECIES DIVERSITY, 3

128 AUTH KOEHLER G. M., HORNOCKER M. G.
DATE 1977.
TITL FIRE EFFECTS ON MARTEN HABITATS.
PUBL J. WILDL. MANAGE. 41(3):500-505.
ANNO DESCRIBES THE EFFECTS OF FIRE ON MARTEN HABITAT AND FOOD SOURCES.
KEYS MARTEN, VOLES, DEER MOUSE, CHIPMUNKS, PREDATION, HABITAT, IDAHO, FOOD HABITS, SMALL MAMMALS, PREDATORS, WILDFIRE, 2

129 AUTH KOEHLER G. M., MOORE W. R., TAYLOR A. R.
DATE 1975.
TITL PRESERVING THE PINE MARTEN MANAGEMENT GUIDELINES FOR WESTERN FORESTS.
PUBL WESTERN WILDLANDS 2(3):31-36.
ANNO DESCRIBES MARTEN HABITAT REQUIREMENTS AND FOOD HABITS. GIVES GUIDELINES FOR FOREST MANAGEMENT FOR MARTEN HABITAT.
KEYS MARTEN, HABITAT, FOOD HABITS, PREDATION, SMALL MAMMALS, IDAHO, MOSAIC, WILDFIRE, LOGGING, 3

130 AUTH KOMAREK E. V. SR.
DATE 1963.
TITL FIRE, RESEARCH, AND EDUCATION.
PUBL TALL TIMBERS FIRE ECOL. CONF. 2:181-187.
ANNO COTTON RATS DECREASED AND GOLDEN MICE AND COTTON MICE INCREASED WHEN AN OPEN PINE WOODS WAS PROTECTED FROM FIRE FOR 4 YEARS. NONE OF THE 52 COTTON RATS ON A 4 ACRE BROOM-SEDGE FIELD WERE HARMED WHEN THE FIELD WAS BURNED AND ONLY 6 WERE SEEN ON THE FIRE BREAK. THE REST HAD TAKEN REFUGE IN 'POP HOLES'.
KEYS COTTON RAT, GOLDEN MOUSE, COTTON MOUSE, MORTALITY, POPULATION DENSITY, SOUTHEAST, SMALL MAMMALS, PRESCRIBED FIRE, 2

131 AUTH KOMAREK E. V. SR.
DATE 1965.
TITL FIRE ECOLOGY-GRASSLANDS AND MAN.
PUBL TALL TIMBERS FIRE ECOL. CONF. 4:169-220.
ANNO DESCRIBES DIRECT AND INDIRECT EFFECTS OF FIRE ON PREDATORS AND PREY IN GRASSLAND.
KEYS COTTON RAT, HOUSE MOUSE, OLDFIELD MOUSE, GRAY FOX, RED FOX, SHRIKE, RAPTORS, PREDATION, BEHAVIORAL ADAPTATIONS, GRASSLAND, SMALL MAMMALS, WILDFIRE, 2

132 AUTH KOMAREK E. V. SR.
DATE 1969.
TITL FIRE AND ANIMAL BEHAVIOR.
PUBL TALL TIMBERS FIRE ECOL. CONF. 9:161-207.
ANNO DESCRIBES BEHAVIORAL ADAPTATIONS OF ANIMALS TO FIRE.
KEYS COTTON RAT, RABBITS, LARGE MAMMALS, REPTILES, AMPHIBIANS, BIRDS, MORTALITY, PREDATION, BEHAVIORAL ADAPTATIONS, SMALL MAMMALS, WILDFIRE, 1

133 AUTH KOMAREK R.
DATE 1963.
TITL FIRE AND THE CHANGING WILDLIFE HABITAT.
PUBL TALL TIMBERS FIRE ECOL. CONF. 5:177-194.
ANNO DISCUSSES THE EFFECTS OF FIRE ON PREY AND PREDATOR POPULATIONS.
KEYS DEER MOUSE, COLUMBIAN GROUND SQUIRREL, MOUNTAIN LION, COYOTE, BEAVER, MARTEN, LARGE MAMMALS, POPULATION DENSITY, PREDATION, SMALL MAMMALS, WILDFIRE, PRESCRIBED FIRE, 2, PREDATORS

134 AUTH KORSCHGEN L. J.
DATE 1957.
TITL FOOD HABITS--COYOTES, FOXES, HOUSE CATS, BOBCATS--IN MISSOURI.
PUBL MISSOURI CONSERV. COMM. P-R REP. 15, 64P.
ANNO STUDY OF THE PRINCIPLE FOODS OF COYOTES, FOXES, HOUSECATS, AND BOBCATS. RABBITS WERE GENERALLY THE MOST IMPORTANT PREY SPECIES.
KEYS PREDATORS, COYOTE, RED FOX, GRAY FOX, BOBCAT, HOUSECAT, SMALL MAMMALS, MISSOURI, BIRDS, 2

135 AUTH KREFTING L. W., AHLGREN C. E.
DATE 1974.
TITL SMALL MAMMALS AND VEGETATION CHANGES AFTER FIRE IN A MIXED CONIFER HARDWOOD FOREST.
PUBL ECOLOGY 55(6):1391-1398.
ANNO DEER MICE WERE THE MOST ABUNDANT SMALL MAMMALS ON 2 WILDFIRE AREAS IN MINNESOTA FOR THE FIRST 7 YEARS. LATER RED-BACKED VOLES INCREASED APPARENTLY IN RESPONSE TO VEGETATION CHANGES. FOOD AND COVER ARE IMPORTANT INFLUENCES ON SMALL MAMMAL POPULATIONS AFTER FIRE.
KEYS SMALL MAMMALS, POST-FIRE SUCCESSION, POPULATION DENSITY, DEER MOUSE, RED-BACKED VOLES, MEADOW VOLE, FOOD HABITS, HABITAT, MIXED CONIFER-HARDWOOD, MINNESOTA, WILDFIRE, 1

136 AUTH LAWRENCE G. E.
DATE 1966.
TITL ECOLOGY OF VERTEBRATE ANIMALS IN RELATION TO CHAPARRAL FIRE IN THE SIERRA NEVADA FOOTHILLS.
PUBL ECOLOGY 47(2):278-291.
ANNO REPORTS ON FIRE MORTALITY OF SMALL MAMMALS. MORTALITY FROM POST-FIRE PREDATION WAS CONSIDERED MORE SIGNIFICANT THAN FIRE MORTALITY. SPECIES CHANGED FROM BRUSH-DWELLING TO GRASS DWELLING BIRDS AND SMALL MAMMALS.
KEYS SMALL MAMMALS, BIRDS, PREDATORS, RAPTORS, POPULATION DENSITY, SPECIES DIVERSITY, MORTALITY, CHAPARRAL, CALIFORNIA, HABITAT, PRESCRIBED FIRE, RELATIVE HUMIDITY, 1

137 AUTH LAWRENCE W. H.
DATE 1954.
TITL MICHIGAN BEAVER POPULATIONS AS INFLUENCED BY FIRE AND LOGGING.
PUBL PH.D. DISSERTATION, UNIV. MICH., ANN ARBOR. 219P.

ANNO BEAVER WERE STUDIED AS A COMPONENT OF THE FOREST COMMUNITY. FIRE, WINTHROW, AND LUMBERING HAVE MAJOR ROLES IN THE DISTRIBUTION AND ABUNDANCE OF BEAVER BY PROVIDING FAVORABLE HABITAT. SUGGESTS INTEGRATING BEAVER MANAGEMENT INTO THE FOREST MANAGEMENT PROGRAM AS A PART OF THE NATURALLY OCCURRING ASPEN-CONIFER SUCCESSIONAL CYCLE.
KEYS SMALL MAMMALS, BEAVER, LOGGING, FIRE, MICHIGAN, ASPEN, PLANT SUCCESSION, 1

138 AUTH LENSINK C. J., SKOOG R. O., BUCKLEY J. L.
DATE 1955.
TITL FOOD HABITS OF MARTEN IN INTERIOR ALASKA AND THEIR SIGNIFICANCE.
PUBL J. WILDL. MANAGE. 19(3):364-368.
ANNO MARTEN SHOW GREAT FLEXIBILITY IN THEIR DIET. FOOD PLAYS A VERY IMPORTANT ROLE IN THE BEHAVIOR, MOVEMENTS AND SELECTION OF HABITAT BY MARTEN.
KEYS MARTEN, FOOD HABITS, PREDATION, ALASKA, PREDATORS, 2

139 AUTH LOBUE J., DARNELL R. M.
DATE 1959.
TITL EFFECT OF HABITAT DISTURBANCE ON A SMALL MAMMAL POPULATION.
PUBL J. MAMMAL. 40:425-437.
ANNO PRAIRIE DEER MICE SHOWED A POSITIVE RESPONSE TO REDUCED VEGETATION AFTER MOWING, WHILE MICROTUS PREFERRED COVER. FOLLOWING MOWING THERE WAS A CHANGE IN SEX RATIO AND IN THE INFLUX OF NEW INDIVIDUALS IN THE DISTURBED AREA.
KEYS SMALL MAMMALS, MEADOW VOLE, DEER MOUSE, MOWING, HABITAT, ALFALFA, MIGRATION, VEGETATION STRUCTURE, 2

140 AUTH LONG C. A., KERFOOT W. C.
DATE 1963.
TITL MAMMALIAN REMAINS FROM OWL-PELLETS IN EASTERN WYOMING.
PUBL J. MAMMAL. 44(1):129-131.
ANNO LIST OF SMALL MAMMALS FOUND IN OWL PELLETS.
KEYS BIRDS, SMALL MAMMALS, OWLS, PREDATION, WYOMING, 3

141 AUTH LOWE P. O.
DATE 1975.
TITL POTENTIAL WILDLIFE BENEFITS OF FIRE IN PONDEROSA PINE FORESTS.
PUBL M.S. THESIS. UNIV. ARIZONA, TUCSON.
ANNO QUANTIFICATION OF WILDLIFE BENEFITS FROM WILDFIRE IN TERMS OF TIME TREND RESPONSE CURVES CONVERTED TO ANNUITIES OR ANNUALIZED RETURN FROM THE RESOURCE. BENEFITS WERE EXPECTED FOR SOME RODENTS BUT LOSSES COULD BE EXPECTED FOR COTTONTAIL AND CHIPMUNKS.
KEYS WILDFIRE, SMALL MAMMALS, LARGE MAMMALS, BIRDS, ARIZONA, HABITAT, COTTONTAIL RABBIT, CHIPMUNKS, RODENTS, PONDEROSA PINE, 2

142 AUTH LOWE P. O., FFOLLIOTT P. F., DIETERICH J. H., PATTON D. R.
DATE 1978.
TITL DETERMINING POTENTIAL WILDLIFE BENEFITS FROM WILDFIRE IN ARIZONA PONDEROSA PINE FORESTS.
PUBL USDA FOR. SERV. GEN. TECH. REP. RM-52. 12P. ROCKY MT. FOR. AND RANGE EXP. STN., FORT COLLINS, CO.
ANNO WILDLIFE USE OF BURNED AREAS WAS EVALUATED AND CONVERTED TO DOLLAR VALUES OF BENEFITS TO WILDLIFE. WILDLIFE USE OF AREAS 1, 3, 7, AND 20 YEARS AFTER FIRE WAS STUDIED.

KEYS RODENTS, WHITE-TAILED DEER, ELK, BIRDS, POST-FIRE SUCCESSION, FOOD HABITS, HABITAT, PONDEROSA PINE, ARIZONA, POPULATION DENSITY, SMALL MAMMALS, LARGE MAMMALS, WILDFIRE, 3

143 AUTH LUBINA J. A.
DATE 1978.
TITL THE EFFECTS OF FIRE ON RODENT POPULATIONS IN THE CHAPARRAL OF SOUTHERN CALIFORNIA: A COMPARATIVE APPROACH.
PUBL M.A. THESIS. CALIF. STATE UNIV., LONG BEACH. 98P.
ANNO FIRE CAUSED A REDUCTION IN SHRUB COVER AND AN INCREASE IN HERBACEOUS VEGETATION. AS A RESULT, THE AGILE KANGAROO RAT INCREASED IN NUMBERS, THE DUSKY-FOOTED WOODRAT DECREASED, DEER MICE AND CALIFORNIA VOLES COLONIZED THE BURNED SITE AND BRUSH MICE DISAPPEARED. POCKET MICE AND CALIFORNIA VOLE DENSITIES WERE LEAST AFFECTED BY THE FIRE. THE INDIRECT IMPACT OF CHANGE IN VEGETATION STRUCTURE WAS THE MOST IMPORTANT IMPACT OF THE FIRE.
KEYS SMALL MAMMALS, FIRE, CHAPARRAL, CALIFORNIA, SPECIES COMPOSITION, POPULATION DENSITY, VEGETATION STRUCTURE, 1, KANGAROO RATS, DUSKY-FOOTED WOODRAT, DEER MOUSE, CALIFORNIA VOLE, BRUSH MOUSE

144 AUTH LUTZ H. J.
DATE 1956.
TITL THE ECOLOGICAL EFFECTS OF FOREST FIRES IN THE INTERIOR OF ALASKA.
PUBL U.S. DEP. AGRIC. TECH. BULL. 1133. 121P.
ANNO FIRE CAUSES THE DISAPPEARANCE OF MARTEN. SMALL MAMMALS WHICH ARE FOOD FOR PREDATORS ARE KILLED WHEN THEIR HABITAT BURNS.
KEYS MARTEN, ALASKA, SMALL MAMMALS, PREDATORS, WILDFIRE, BIRDS, FISHER, LYNX, ERMINE, LARGE MAMMALS, HABITAT, 3

145 AUTH LYON L. J., CRAWFORD H. S., CZUHAI E., FREDRIKSEN R.L., HARLOW R. F., METZ L. J., PEARSON H. A.
DATE 1978.
TITL EFFECTS OF FIRE ON FAUNA A STATE OF THE ART REVIEW.
PUBL USDA FOR. SERV. GEN. TECH. REP. WO-6, 41P.
ANNO REVIEW OF THE LITERATURE ON THE EFFECTS OF FIRE ON ANIMALS, INCLUDING INVERTEBRATES.
KEYS FIRE, SMALL MAMMALS, LARGE MAMMALS, BIRDS, HABITAT, VEGETATION STRUCTURE, MORTALITY, BIBLIOGRAPHY, 1

146 AUTH MANVILLE R. H.
DATE 1959.
TITL THE COLUMBIAN GROUND SQUIRREL IN NORTHWESTERN MONTANA.
PUBL J. MAMMAL. 40(1):26-45.
ANNO A LIFE HISTORY OF COLUMBIAN GROUND SQUIRRELS IN GLACIER NATIONAL PARK.
KEYS SMALL MAMMALS, COLUMBIAN GROUND SQUIRREL, MONTANA, 2

147 AUTH MARSHALL J. T. JR.
DATE 1942.
TITL FOOD AND HABITAT OF THE SPOTTED OWL.
PUBL CONDOR 44(2):66-67.
ANNO SPOTTED OWL PREYS ON SMALL MAMMALS, BIRDS, AND CRICKETS. HABITAT RATHER THAN FOOD SEEM TO LIMIT DISTRIBUTION.
KEYS RAPTORS, PREDATION, SMALL MAMMALS, SPOTTED OWL, TRANSITION ZONE FOREST, OREGON, BIRDS, 3

148 AUTH MARSHALL W. H.
DATE 1942.
TITL THE BIOLOGY AND MANAGEMENT OF THE PINE MARTEN IN IDAHO.
PUBL PH.D. DISSERTATION, UNIV. MICH., ANN ARBOR. 107P.
ANNO DESCRIBES BIOLOGY, HABITAT, MOVEMENTS, AND FOOD OF THE PINE MARTEN. PRIMARY FOOD ITEMS WERE FLYING SQUIRREL, RED SQUIRREL, SNOWSHOE HARE, RED-BACKED VOLE, BIG GAME CARCASSES, SHREWS, AND BERRIES. FIR AND SPRUCE FIR HABITAT WERE USED THE MOST, BUT CONCLUDES THAT FOOD SUPPLY MAY BE MORE IMPORTANT THAN COVER TYPE. LOGGING ON SMALL SCALE WAS NOT DETRIMENTAL. SINCE FIRE CONTROL WAS GOOD, CATESTROPHIC FIRE WAS NOT EXPECTED TO ELIMINATE HABIT. MAKES MANAGEMENT SUGGESTIONS ESPECIALLY PERTAINING TO TRAPPING.
KEYS MARTEN, SMALL MAMMALS, PREDATORS, IDAHO, SPRUCE-FIR, HABITAT, FOOD HABITS, 2

149 AUTH MARSHALL W. H.
DATE 1946.
TITL WINTER FOOD HABITS OF THE PINE MARTEN IN MONTANA.
PUBL J. MAMMAL. 27:83-84.
ANNO RED SQUIRRELS, RED-BACKED VOLES AND SNOWSHOE HARE WERE MOST IMPORTANT FOOD ITEMS FOR MARTEN IN MONTANA.
KEYS PREDATORS, MARTEN, FOOD HABITS, MONTANA, RED SQUIRREL, RED-BACKED VOLES, SNOWSHOE HARE, SMALL MAMMALS, 2

150 AUTH MARSHALL W. H.
DATE 1951.
TITL PINE MARTEN AS A FOREST PRODUCT.
PUBL J. FOR. 49(2):899-905.
ANNO DISCUSSES MARTEN ECOLOGY- FOOD, HABITAT, REPRODUCTION. MAKES SUGGESTIONS FOR MANAGING MARTEN AS A FOREST PRODUCT FOR TRAPPERS. MENTIONS EFFECTS OF LOGGING AND FIRE SUPPRESSION ON MARTEN.
KEYS MARTEN, PREDATORS, IDAHO, MONTANA, HABITAT, FOOD HABITS, SMALL MAMMALS, BIRDS, POPULATION DENSITY, FIRE SUPPRESSION, 2, LOGGING

151 AUTH MARSTON R. B., JULANDER O.
DATE 1961.
TITL PLANT COVER REDUCTIONS BY POCKET GOPHERS FOLLOWING EXPERIMENTAL REMOVAL OF ASPEN FROM A WATERSHED AREA IN UTAH.
PUBL J. FOR. 59(2):100-102.
ANNO POCKET GOPHERS REDUCED PLANT COVER ON EXPERIMENTAL PLOT WHERE ASPEN HAD BEEN REMOVED TO THE EXTENT THAT THERE WAS CONCERN ABOUT POTENTIAL EROSION.
KEYS SMALL MAMMALS, POCKET GOPHERS, LOGGING, ASPEN, UTAH, FOOD HABITS, POPULATION DENSITY, 2

152 AUTH MARTELL A. M.
DATE 1978
TITL SELECTION OF CONIFER SEEDS BY DEER MICE AND RED-BACKED VOLES.
PUBL CAN. J. FOR. 9(2):201-204.
ANNO IN LABORATORY EXPERIMENTS, BOTH DEER MICE AND RED-BACKED VOLES STRONGLY PREFERRED THE SEEDS OF WHITE PINE OVER THOSE OF JACKPINE OR BLACK SPRUCE.
KEYS SMALL MAMMALS, DEER MOUSE, RED-BACKED VOLES, SEED, WHITE PINE, JACK PINE, BLACK SPRUCE, 3

153 AUTH MASER C., GASHWILER J. S.
DATE 1978.
TITL INTERRELATIONSHIPS OF WILDLIFE AND WESTERN JUNIPER.
PUBL IN PROCEEDINGS OF THE WESTERN JUNIPER ECOLOGY AND MANAGEMENT WORKSHOP. BEND, ORE. USDA FOR. SERV. GEN. TECH. REP. PNW-74, P. 37-82, 1978. PAC. NORTHWEST AND RANGE EXP. STN., PORTLAND, ORE.
ANNO DESCRIBES WILDLIFE HABITAT (NESTING, FEEDING AND COVER) PROVIDED BY WESTERN JUNIPER, FOR 83 SPECIES OF BIRDS AND 23 SPECIES OF MAMMALS.
KEYS BIRDS, WESTERN JUNIPER, HABITAT, LARGE MAMMALS, SMALL MAMMALS, PREDATORS, 3

154 AUTH MASER C., TRAPPE J. M., NUSSBAUM R. A.
DATE 1978.
TITL FUNGAL-SMALL MAMMAL INTERRELATIONSHIPS WITH EMPHASIS ON OREGON CONIFEROUS FORESTS.
PUBL ECOLOGY 59(4):799-809.
ANNO ALTHOUGH SMALL MAMMALS MAY IMPEDE REFORESTATION THEY ARE ALSO IMPORTANT FOR REFORESTATION AS VECTORS FOR MYCORRHIZAL DISPERSAL.
KEYS SMALL MAMMALS, FOOD HABITS, MYCORRHIZAL FUNGI, OREGON

155 AUTH MASER C., TRAPPE J. M., URE D. C.
DATE 1978.
TITL IMPLICATIONS OF SMALL MAMMAL MYCOPHAGY TO THE MANAGEMENT OF WESTERN FORESTS.
PUBL TRANS. NORTH AM. WILDL. NAT. RESOUR. CONF. 43:78-88.
ANNO THERE IS A COMPLEX INTERRELATIONSHIP BETWEEN TREES, MYCORRHIZAL FUNGI, AND SMALL MAMMALS. IN MANAGING FORESTS ALL OF THESE INTERACTIONS NEED TO BE CONSIDERED.
KEYS SMALL MAMMALS, FOOD HABITS, MYCORRHIZAL FUNGI, CONIFEROUS FOREST

156 AUTH MCGEE J. M.
DATE IN PRESS.
TITL SMALL MAMMAL RESPONSES TO PRESCRIBED BURNING OF BIG SAGE BRUSH.
PUBL J. RANGE MANAGE.
KEYS SMALL MAMMALS, SAGEBRUSH, PRESCRIBED FIRE, WYOMING, SPRING BURN, FALL BURN, 2, GRAND TETON NATIONAL PARK, POSTFIRE SUCCESSION, MOSAIC, SPECIES COMPOSITION, MASKED SHREW, VAGRANT SHREW, LEAST CHIPMUNK, DEER MOUSE, MEADOW VOLE, MONTANA VOLE, WESTERN JUMPING MOUSE, LONG-TAILED WEASEL, PREDATORS

157 AUTH MCGEE J. M.
DATE 1976.
TITL SOME EFFECTS OF FIRE SUPPRESSION AND PRESCRIBED BURNING ON BIRDS AND SMALL MAMMALS IN SAGEBRUSH.
PUBL PH.D. DISSERTATION. UNIV. WYOMING, LARAMIE. 134P.
ANNO CHANGES IN BIRD DENSITY AND DIVERSITY AFTER BURNING SAGEBRUSH LASTED ONLY 2-3 YEARS. TOTAL SMALL MAMMAL NUMBERS WERE NOT DEPLETED BY FIRE, BUT EACH SPECIES RESPONDED DIFFERENTLY TO HABITAT CHANGES CAUSED BY THE BURNING.
KEYS SMALL MAMMALS, BIRDS, SAGEBRUSH, FIRE SUPPRESSION, PRESCRIBED FIRE, WYOMING, SPRING BURN, FALL BURN, POPULATION DENSITY, SPECIES DIVERSITY, GRAND TETON NATIONAL PARK, POSTFIRE SUCCESSION, MOSAIC, DEER MOUSE, 2

158 AUTH MCGREGOR R. C.
DATE 1958.
TITL SMALL MAMMAL STUDIES ON A SOUTHEAST ALASKA CUTOVER AREA.
PUBL USDA FOR. SERV. STN. PAP. NO. 8. 9P. ALASKA FOR. RES. CENTER, JUNEAU, ALASKA.
ANNO WHITE-FOOTED MOUSE POPULATIONS IN LOGGED AREAS AVERAGED 1.2-4 PER ACRE. THEY WERE MOST ABUNDANT ON THE VALLEY BOTTOM. SHREWS WERE MOST NUMEROUS ON SIDEHILLS, AND VOLES IN GRASSY AREAS.
KEYS SMALL MAMMALS, ALASKA, LOGGING, POISONS, POPULATION DENSITY, 2, CLEARCUT, WHITE-FOOTED MOUSE, SHREWS, VOLES

159 AUTH MCKAY D. D., VERTS B. J.
DATE 1978.
TITL HABITAT PREFERENCE AND DISPERSAL OF NUTTALLS COTTONTAILS.
PUBL NORTHWEST SCI. 52(4):363-368.
ANNO DISCUSSES THE EFFECT OF SAMPLING BIAS ON THE ESTIMATION OF HABITAT PREFERENCE IN NUTTAILS COTTONTAILS.
KEYS SMALL MAMMALS, NUTTALL'S COTTONTAIL, OREGON, HABITAT, 3

160 AUTH MCKEEVER S.
DATE 1960.
TITL FOOD OF THE NORTHERN FLYING SQUIRREL IN NORTHEASTERN CALIFORNIA.
PUBL J. MAMMAL. 41:270-271.
ANNO DURING THE SUMMER, FUNGI WERE THE PRINCIPLE FOOD OF FLYING SQUIRRELS EXAMINED IN LASSEN COUNTY, CALIFORNIA. HAIR MOSS WAS THE PRINCIPLE FOOD DURING THE WINTER WHEN SNOW COVERED THE GROUND.
KEYS SMALL MAMMALS, FLYING SQUIRRELS, FOOD HABITS, CALIFORNIA, FUNGI, 3

161 AUTH MECH D. L., ROGERS L. L.
DATE 1977.
TITL STATUS, DISTRIBUTION, AND MOVEMENTS OF MARTENS IN NORTHEASTERN MINNESOTA.
PUBL USDA FOR. SERV. RES. PAP. NC-143, 7P. NORTH CENT. FOR EXP. STN., ST. PAUL, MINN.
ANNO INFORMATION ON MARTEN DENSITY AND HABITAT. HOME RANGES OF 4 TELEMETERED MARTEN RANGED FROM 4.3 TO 19.9 KM2.
KEYS MARTEN, MOVEMENTS, POPULATION DENSITY, HABITAT, MINNESOTA, PREDATORS, 3

162 AUTH MEEHAN W.R.
DATE 1974.
TITL THE FOREST ECOSYSTEM OF SOUTHEAST ALASKA. 4. WILDLIFE HABITATS.
PUBL USDA FOR. SERV. GEN. TECH. REP. PNW-16. 32P. PACIFIC NORTHWEST FOREST AND RANGE EXP. STN., PORTLAND, ORE.
ANNO DISCUSSES THE IMPACTS OF MAN'S ACTIVITIES INCLUDING LOGGING, ON WILDLIFE HABITATS.
KEYS SMALL MAMMALS, PREDATORS, ALASKA, LOGGING, HABITAT, LARGE MAMMALS, 3

163 AUTH METZGAR L. H.
DATE 1967.
TITL AN EXPERIMENTAL COMPARISON OF SCREECH OWL PREDATION ON RESIDENT AND TRANSIENT WHITE-FOOTED MICE (PEROMYSCUS LEUCOPUS).
PUBL J. MAMMAL. 48(3):387-391.
ANNO TRANSIENT MICE WERE MORE SUSCEPTABLE TO PREDATION BY A SCREECH OWL THAN RESIDENT MICE.

KEYS SMALL MAMMALS, RAPTORS, OWLS, PREDATION, WHITE-FOOTED MOUSE, 2, BIRDS

164 AUTH MILLER R. G., RITCEY R. W., EDWARDS R. Y.
DATE 1955.
TITL LIVE TRAPPING MARTEN IN BRITISH COLUMBIA.
PUBL MURRELET 36(1):1-8.
ANNO LOGGING AND FIRE DESTROYS MARTEN HABITAT. MODERN CUTTING, MAINTAINING FOREST STANDS OF DIFFERENT AGES, AND PRESERVING OLD GROWTH MARTEN HABITAT, WILL PERPETUATE MARTEN HABITAT.
KEYS MARTEN, BRITISH COLUMBIA, LOGGING, FIRE, HABITAT, HOME RANGE, PREDATORS, 2

165 AUTH MOORE A. W.
DATE 1940.
TITL WILD ANIMAL DAMAGE TO SEED AND SEEDLINGS ON CUTOVER DOUGLAS FIR LANDS OF OREGON AND WASHINGTON.
PUBL U.S. DEP. AGRIC. TECH. BULL. NO. 706. 27P. WASHINGTON, D.C.
ANNO DESCRIBES THE IMPACTS OF WHITE-FOOTED MICE, SHREWS, OTHER MAMMALS, AND BIRDS, ON REFORESTATION.
KEYS SMALL MAMMALS, OREGON, WASHINGTON, DOUGLAS-FIR, SLASH FIRE, LOGGING, SEED, FOOD HABITS, WHITE-FOOTED MOUSE, SHREWS, BIRDS, 3

166 AUTH MOORE A. W.
DATE 1942.
TITL SHREWS AS A CHECK ON DOUGLAS-FIR REGENERATION.
PUBL J. MAMMAL. 23(1):37-41.
ANNO DISCOVERED SEED EATERS BY LIVETRAPPING WITH SEED FOR BAIT. OREGON COASTAL SHREWS EAT CONSIDERABLE QUANTITIES OF DOUGLAS-FIR SEED AND MAY BE THE REASON THERE ISN'T MORE DOUGLAS-FIR REGENERATION.
KEYS SMALL MAMMALS, SHREWS, SEED, FOOD HABITS, OREGON, DOUGLAS-FIR, SLASH FIRE, 3

167 AUTH MOORE A. W.
DATE 1943.
TITL THE POCKET GOPHER IN RELATION TO YELLOW PINE REPRODUCTION.
PUBL J. MAMMAL. 24(2):271-272.
ANNO IN AREAS GRAZED BY CATTLE, DEER MICE TRAVELING IN POCKET GOPHER BURROWS APPARENTLY CONSUMED PONDEROSA PINE SEED. POCKET GOPHERS WERE NOT EATING THE SEED.
KEYS SMALL MAMMALS, POCKET GOPHERS, DEER MOUSE, GRAZING, OREGON, SEED, PONDEROSA PINE, 3, FOOD HABITS

168 AUTH MORE G.
DATE 1978.
TITL ECOLOGICAL ASPECTS OF FOOD SELECTION IN PINE MARTEN (MARTES AMERICANA).
PUBL M.S. THESIS. UNIV. ALBERTA, EDMONTON. 94P.
KEYS PREDATORS, MARTEN, FOOD HABITS, 2

169 AUTH MORRIS R. D.
DATE 1970.
TITL THE EFFECTS OF ENDRIN ON MICROTUS AND PEROMYSCUS. 1. UNENCLOSED FIELD POPULATIONS.
PUBL CAN. J. ZOOL. 48(4):695-708.
ANNO DEER MOUSE POPULATIONS WERE SIGNIFICANTLY REDUCED AFTER SPRAYING ENDRIN AND DID NOT RECOVER. VOLES DECLINED IMMEDIATELY

AFTER SPRAYING BUT IN 2 YEARS VOLE POPULATIONS EXCEEDED PRESPRAY LEVELS, AND EXCEEDED POPULATIONS ON CONTROL AREAS EACH YEAR OF THE STUDY.
KEYS SMALL MAMMALS, INSECTICIDE, POPULATION DENSITY, DEER MOUSE, MEADOW VOLE, 3

170 AUTH MORRIS R. F., CHESHIRE W. F., MILLER C. A., MOTT D. G.
DATE 1958.
TITL THE NUMERICAL RESPONSE OF AVIAN AND MAMMALIAN PREDATORS DURING A GRADATION OF THE SPRUCE BUDWORM.
PUBL ECOLOGY 39(3):487-494.
ANNO RODENT AND INSECTIVORE POPULATIONS FLUCTUATED INDEPENDANTLY OF BUDWORM DENSITY; HOWEVER, RED-BACKED VOLE AND DEER MOUSE POPULATION CYCLES HAD DEPRESSED PEAKS, POSSIBLY BECAUSE OF SEED SHORTAGE DURING BUDWORM OUTBREAK.
KEYS BIRDS, SMALL MAMMALS, SPRUCE BUDWORM, FOOD HABITS, POPULATION DENSITY, CONIFEROUS FOREST, CANADA, 2

171 AUTH MOTOBU D. A.
DATE 1978.
TITL EFFECTS OF CONTROLLED SLASH BURNING ON THE MOUNTAIN BEAVER (APLODONTIA RUFA RUFA).
PUBL NORTHWEST SCI. 52(2):92-99.
ANNO SLASH BURNING WAS CONSIDERED SUCCESSFUL FOR REDUCING MOUNTAIN BEAVER POPULATIONS. LOSSES WERE A RESULT OF ANIMALS BEING KILLED BY THE FIRE. SURVIVORS REMAINED WITHIN THEIR HOME RANGES. PREDATORS WERE ATTRACTED BY ROTTING CARCASSES.
KEYS SMALL MAMMALS, MOUNTAIN BEAVER, WASHINGTON, SLASH FIRE, MORTALITY, PREDATORS, COYOTE, RAPTORS, LONG-TAILED WEASEL, DOUGLAS-FIR, LOGGING, HOME RANGE, 2

172 AUTH MURIE A.
DATE 1940.
TITL ECOLOGY OF THE COYOTE IN YELLOWSTONE.
PUBL FAUNA OF THE NATIONAL PARKS OF THE U.S. FAUNA SERIES NO 4. U.S. GOVT. PRINTING OFFICE, WASHINGTON, D.C. 206P.
ANNO LIFE HISTORY OF THE COYOTE IN YELLOWSTONE NATIONAL PARK.
KEYS 1, PREDATORS, COYOTE, YELLOWSTONE NATIONAL PARK, WYOMING, MONTANA

173 AUTH MURIE A.
DATE 1961.
TITL SOME FOOD HABITS OF THE MARTEN.
PUBL J. MAMMAL. 42(4):516-521.
ANNO VOLES WERE PRESENT IN 251 OF 384 MARTEN SCATS. BERRIES WERE IMPORTANT FOOD ITEMS. RED SQUIRREL NESTS WERE USED BY MARTEN FOR A FEW DAYS AT A TIME ALTHOUGH THE SQUIRRELS WERE RARELY PREYED UPON.
KEYS MARTEN, FOOD HABITS, PREDATION, PREDATORS, SMALL MAMMALS, VOLES, RED SQUIRREL, GRAND TETON NATIONAL PARK, PIKA, 2, WYOMING

174 AUTH MURIE O. J.
DATE 1945.
TITL NOTES ON COYOTE FOOD HABITS IN MONTANA AND BRITISH COLUMBIA.
PUBL J. MAMMAL. 26(1):33-40.
ANNO NOTES OF FOOD HABITS FROM SCAT COLLECTIONS MADE FROM 1934-1935. IN THESE SCATS SNOWSHOE HARE AND COTTONTAILS WERE THE MOST ABUNDANT FOOD ITEM. CONCLUDES THAT COYOTES WILL SEEK AN

ABUNDANT AND EASY TO CAPTURE PREY SPECIES.
KEYS COYOTE, PREDATORS, PREDATION, FOOD HABITS, MONTANA, BRITISH COLUMBIA, SMALL MAMMALS, SNOWSHOE HARE, BIRDS, LARGE MAMMALS, 2

175 AUTH NEGUS N. C., FINDLEY J.
DATE 1959.
TITL MAMMALS OF JACKSON HOLE, WYOMING.
PUBL J. MAMMAL. 40(3):371-381.
ANNO LISTING OF SPECIES FOUND IN JACKSON HOLE. HABITAT INFORMATION GIVEN ON SMALL MAMMALS.
KEYS SMALL MAMMALS, PREDATORS, LARGE MAMMALS, WYOMING, HABITAT, 3

176 AUTH NEWBY F. E., MCDOUGAL J. J.
DATE 1964.
TITL RANGE EXTENSION OF THE WOLVERINE IN MONTANA.
PUBL J. MAMMAL. 45(3):483-487.
ANNO WOLVERINE INCREASING IN MONTANA.
KEYS PREDATORS, WOLVERINE, MONTANA, POPULATION DENSITY, 3

177 AUTH ODUM E. P.
DATE 1944.
TITL WATER CONSUMPTION OF CERTAIN MICE IN RELATION TO HABITAT SELECTION.
PUBL J. MAMMAL. 25(4):404-405.
ANNO CAPTIVE RED-BACKED VOLES DRANK NEARLY THEIR WEIGHT IN WATER EACH DAY, ALMOST 10 TIMES AS MUCH WATER AS DEER MICE. IN THE WILD THEY CHOSE THE WETTEST HABITAT.
KEYS SMALL MAMMALS, HABITAT, RED-BACKED VOLES, DEER MOUSE, MOISTURE REQUIREMENTS, 2,

178 AUTH ODUM E. P., POMEROY S. E., DICKINSON J. C. III, HUTCHESON K.
DATE 1973.
TITL THE EFFECTS OF LATE WINTER LITTER BURN ON THE COMPOSITION, PRODUCTIVITY AND DIVERSITY OF A 4-YEAR OLD FALLOW-FIELD IN GEORGIA.
PUBL TALL TIMBERS FIRE ECOL. CONF. 13:399-419.
ANNO SIGMODON, MUS, PEROMYSCUS, AND REITHRODONTOMYS WERE INTRODUCED INTO FENCED, PARTIALLY BURNED PLOTS. SIGMODON INCREASED IN NUMBERS, MUS AND PEROMYSCUS POPULATIONS REMAINED LOW, AND REITHRODONTOMYS BECAME EXTINCT.
KEYS SMALL MAMMALS, COTTON RAT, EASTERN HARVEST MOUSE, OLDFIELD MOUSE, HOUSE MOUSE, PRESCRIBED FIRE, GEORGIA, POPULATION DENSITY, 3

179 AUTH OHMANN L. F., CUSHWA C. T., LAKE R. E., BEER J. R., BRANDER R. B.
DATE 1973.
TITL WILDERNESS ECOLOGY: THE UPLAND PLANT COMMUNITIES, WOODY BROWSE, PRODUCTION, AND SMALL MAMMALS OF TWO ADJACENT 33-YEAR-OLD WILDFIRE AREAS OF NORTHEASTERN MINNESOTA.
PUBL USDA FOR. SERV. GEN. TECH. REP. NC-7, 30P. NORTH CENT. FOR. EXP. STN., ST. PAUL, MINN.
ANNO AN ATTEMPT TO RELATE SMALL MAMMAL DISTRIBUTION TO VEGETATIVE COMMUNITY TYPES. INSUFFICIENT NUMBERS OF ANIMALS WERE TRAPPED TO TEST CORRELATIONS, BUT IT APPEARED THAT THE SMALL MAMMALS WERE UNIFORMLY DISTRIBUTED THROUGH THE VEGETATION TYPES TESTED.
KEYS SMALL MAMMALS, MINNESOTA, DEER MOUSE, RED-BACKED VOLES, HABITAT, JACK PINE, BIRCH, ASPEN, 3, WILDFIRE, POST-FIRE SUCCESSION

180 AUTH ORR-EWING A. L.
DATE 1950.
TITL LIFE HISTORY OF THE DEER MOUSE.
PUBL FOR. CHRON. 26(2):115-126.
ANNO CONTROL OF MICE NECESSARY FOR SUCCESSFUL RESEEDING OF DOUGLAS-FIR ON LOGGED AND BURNED LAND. SUGGESTS CORRELATING CONTROL METHODS WITH LIFE HISTORY AND SEASONAL CYCLES OF THE MICE.
KEYS SMALL MAMMALS, DEER MOUSE, LOGGING, PRESCRIBED FIRE, DOUGLAS-FIR, BRITISH COLUMBIA, POPULATION DENSITY, SEED, FOOD HABITS, SHREWS, 3

181 AUTH PANK L. F.
DATE 1974.
TITL A BIBLIOGRAPHY ON SEED-EATING MAMMALS AND BIRDS THAT AFFECT FOREST REGENERATION.
PUBL U.S. DEP. INTERIOR, FISH AND WILDL. SERV. SPEC. SCI. REP., WILDL. NO. 174. WASHINGTON, D.C. 28P.
ANNO BIBLIOGRAPHY ON SEED-EATING MAMMALS AND BIRDS THAT AFFECT FOREST VEGETATION.
KEYS SMALL MAMMALS, BIRDS, SEED, FOOD HABITS, BIBLIOGRAPHY, 3

182 AUTH PATRIC E. F., WEBB W. L., PATTON D. R., FFOLLIOTT P. F.
DATE 1953.
TITL A PRELIMINARY REPORT ON INTENSIVE BEAVER MANAGEMENT.
PUBL TRANS. NORTH AM. WILDL. CONF. 18:533-539.
ANNO REPORTS HIGH BEAVER POPULATIONS DUE TO EXTENSIVE CLEARCUTTING AND FIRES. SUGGESTS FOREST MANAGEMENT TO PRODUCE SUITABLE BEAVER HABITAT.
KEYS SMALL MAMMALS, BEAVER, NEW YORK, POPULATION DENSITY, WILDFIRE, CLEARCUT, POST-FIRE SUCCESSION, ASPEN, 2

183 AUTH PATTON D.R., FFOLLIOTT P.F.
DATE 1975.
TITL SELECTED BIBLIOGRAPHY OF WILDLIFE AND HABITATS FOR THE SOUTHWEST.
PUBL USDA FOR. SERV. GEN. TECH. REP. RM-16. 39P. ROCKY MT. FOR. AND RANGE EXP. STN., FT. COLLINS, COLO.
ANNO 390 REFERENCES ON RESEARCH AND MANAGEMENT OF IMPORTANT WILDLIFE AND HABITATS IN ARIZONA AND NEW MEXICO. DOES NOT INCLUDE AMPHIBIANS, REPTILES, BATS, OR SMALL RODENTS.
KEYS HABITAT, BIBLIOGRAPHY, ARIZONA, NEW MEXICO, SMALL MAMMALS, LARGE MAMMALS, PREDATORS, BIRDS, 3

184 AUTH PEARSON O. P.
DATE 1964.
TITL CARNIVORE-MOUSE PREDATION: AN EXAMPLE OF ITS INTENSITY AND BIOENERGETICS.
PUBL J. MAMMAL. 45(2):177-188.
ANNO PEAK MOUSE POPULATION EXCEEDED ITS FOOD SUPPLY. MORTALITY DUE TO CARNIVORES, OTHER SOURCES, AND EMIGRATION, REDUCED MOUSE POPULATIONS SO THAT 7% OF THE SEED CROP WAS NOT EATEN. EIGHTY-EIGHT PERCENT OF THE 4400 MICROTUS, 33% OF THE 1200 REITHRODONTOMYS, AND 7% OF THE 7000 MUS WERE EATEN BY CARNIVORES.
KEYS SMALL MAMMALS, PREDATORS, PREDATION, POPULATION DENSITY, CALIFORNIA, GRAY FOX, RACCOON, SKUNK, SEED, FOOD HABITS, VOLES, HARVEST MOUSE, HOUSE MOUSE, 2

185 AUTH PELIKAN J., VACKAR J.
DATE 1978.
TITL DENSITIES OF RED FOX, BADGER, AND PINE MARTEN POPULATIONS.
PUBL CONG. THERIOL. INT. 2:189.
KEYS PREDATORS, RED FOX, BADGER, MARTEN, POPULATION DENSITY, 2

186 AUTH PILLMORE R. E., FLICKINGER E. L., RICHMOND M. L.
DATE 1970.
TITL FOREST SPRAYING OF ZECTRAN AND ITS SAFETY TO WILDLIFE.
PUBL J. FOR. 69(10):721-727.
ANNO ZECTRAN SPRAYED TO CONTROL SPRUCE BUDWORMS WAS NOT CONSIDERED HARMFUL TO WILDLIFE. DOCUMENTS THE CONSUMPTION OF SPRUCE BUDWORM LARVAE BY RED SQUIRREL, AND GOLDEN-MANTLED GROUND SQUIRREL, CHIPMUNKS, AND DEER MOUSE.
KEYS SMALL MAMMALS, BIRDS, INSECTICIDE, FOOD HABITS, SPRUCE BUDWORM, 3, RED SQUIRREL, GOLDEN-MANTLED GROUND SQUIRREL, CHIPMUNKS, DEER MOUSE

187 AUTH QUICK H. F.
DATE 1953.
TITL WOLVERINE, FISHER, AND MARTEN STUDIES IN A WILDERNESS REGION.
PUBL TRANS. NORTH AM. WILDL. CONF. 18:513-532.
ANNO PRESENTS INFORMATION ON RANGE, FOOD HABITS AND BEHAVIOR GATHERED FROM RUNNING TRAPLINES FOR THESE SPECIES.
KEYS PREDATORS, MARTEN, FISHER, WOLVERINE, TRAPPING, VOLES, SMALL MAMMALS, BRITISH COLUMBIA, 2

188 AUTH QUICK H. F.
DATE 1954.
TITL SMALL MAMMAL POPULATIONS IN NORTHERN BRITISH COLUMBIA.
PUBL CAN. FIELD-NAT. 68(3):95-102.
ANNO SMALL MAMMAL POPULATIONS STUDIED BECAUSE OF THEIR IMPORTANCE AS FOOD ITEMS FOR FUR-BEARERS. DESCRIPTION OF POPULATION CYCLES.
KEYS SMALL MAMMALS, PREDATORS, FISHER, MARTEN, BRITISH COLUMBIA, POPULATION DENSITY, 2

189 AUTH QUICK H. F.
DATE 1955.
TITL FOOD HABITS OF MARTEN (MARTES AMERICANA) IN NORTHERN BRITISH COLUMBIA.
PUBL CAN. FIELD-NAT. 69(4):144-147.
ANNO THE MARTEN FOOD BASE CONSISTS OF RED-BACKED VOLES, DEER MICE, RED SQUIRRELS, AND SNOWSHOE HARE. THESE ANIMALS VARY IN ABUNDANCE BUT LOW LEVELS DID NOT SEEM TO LIMIT MARTEN. THE PROPORTION OF MARTEN SPECIMENS CONTAINING VOLE REMAINS WAS THE SAME DURING LOW VOLE POPULATIONS AS DURING HIGH VOLE POPULATIONS.
KEYS MARTEN, FOOD HABITS, BRITISH COLUMBIA, PREDATORS, PREDATION, RED-BACKED VOLES, DEER MOUSE, RED SQUIRREL, SNOWSHOE HARE, 2

190 AUTH REAM C. H., GRUELL G. E.
DATE 1980.
TITL INFLUENCES OF HARVESTING AND RESIDUE TREATMENTS ON SMALL MAMMALS AND IMPLICATIONS FOR FOREST MANAGEMENT.
PUBL IN ENVIRONMENTAL CONSEQUENCES OF TIMBER HARVESTING IN ROCKY MOUNTAIN CONIFEROUS FORESTS. SEP. 11-13, 1979, MISSOULA, MT. GEN. TECH. REP. INT-90.
ANNO REVIEW OF THE EFFECTS OF LOGGING AND RESIDUE TREATMENTS ON SMALL MAMMALS. NUMBERS AND SPECIES COMPOSITION ARE RELATED TO

HABITATS WHICH RESULT FROM HARVESTING METHODS. DISCUSSION OF BENEFICIAL AND DETRIMENTAL ASPECTS OF SMALL MAMMALS IN FOREST COMMUNITIES.
KEYS SMALL MAMMALS, SPECIES COMPOSITION, POPULATION DENSITY, DEER MOUSE, RED-BACKED VOLES, COLUMBIAN GROUND SQUIRREL, SHREWS, SNOWSHOE HARE, PORCUPINE, FLYING SQUIRRELS, RED SQUIRREL, PRESCRIBED FIRE, BROADCAST FIRE, CLEARCUT, SELECTIVE CUT, HERBICIDE, INSECTICIDE, POST-FIRE SUCCESSION, BROADCAST FIRE, MOSAIC, POISONS, DAMAGE, SEED, FUNGI, INSECTS, RESIDUE TREATMENTS, 1

191 AUTH RESLER R. A.
DATE 1972.
TITL CLEARCUTTING: BENEFICIAL ASPECTS FOR WILDLIFE RESOURCES.
PUBL J. SOIL WATER CONSERV. 27(6):251-254.
ANNO POINTS OUT POTENTIAL BENEFITS OF CLEARCUTTING TO WILDLIFE IF APPROPRIATE PLANNING PRECEEDS HARVESTING.
KEYS SMALL MAMMALS, LARGE MAMMALS, BIRDS, CLEARCUT, LITERATURE REVIEW, 2

192 AUTH RICKARD W. H.
DATE 1960.
TITL THE DISTRIBUTION OF SMALL MAMMALS IN RELATION TO THE CLIMAX VEGETATION MOSAIC IN EASTERN WASHINGTON AND NORTHERN IDAHO.
PUBL ECOLOGY 41(1):99-106.
ANNO 14 TYPES OF CLIMAX PLANT ASSOCIATIONS SAMPLED FOR SMALL MAMMALS. DISTRIBUTION OF 11 SMALL MAMMAL SPECIES IN DIFFERENT COMMUNITIES DISCUSSED. CHIPMUNKS WERE TRAPPED IN EVERY FOREST STAND. RED-BACKED VOLES WERE TRAPPED IN ALL BUT THE MOST XERIC CONIFEROUS STANDS. SHREWS WERE NOT AS STRONGLY LINKED TO PLANT ASSOCIATIONS AS HERBIVOROUS SMALL MAMMALS.
KEYS SMALL MAMMALS, IDAHO, WASHINGTON, SPECIES COMPOSITION, HABITAT, YELLOW-PINE CHIPMUNK, RED-BACKED VOLES, MASKED SHREW, DUSKY SHREW, DEER MOUSE, 2

193 AUTH ROPPE J. A., HEIN D.
DATE 1978.
TITL EFFECTS OF FIRE IN A LODGEPOLE PINE FOREST.
PUBL SOUTHWEST NAT. 23(2):279-288.
ANNO SPECIES DIVERSITY FOR SMALL MAMMALS AND BIRDS WAS GREATER ON AN 8 YEAR OLD BURN THAN THE ADJACENT UNBURNED LODGEPOLE. POPULATION DENSITIES AND TOTAL BIOMASS WERE SIMILIAR FOR BOTH HABITATS.
KEYS SMALL MAMMALS, LARGE MAMMALS, BIRDS, LODGEPOLE PINE, COLORADO, WILDFIRE, SPECIES COMPOSITION, POPULATION DENSITY, SUMMER BURN, POST-FIRE SUCCESSION, 1

194 AUTH ROSENZEIG M. L.
DATE 1973.
TITL HABITAT SELECTION BY RODENTS.
PUBL ECOLOGY 54(1):110-117.
ANNO KANGAROO RATS AND POCKET MICE COEXIST, EXPLOITING DIFFERENT VEGETATION STRUCTURES WITHIN THE HABITAT.
KEYS SMALL MAMMALS, RODENTS, HABITAT, KANGAROO RATS, POCKET MOUSE, ARIZONA, VEGETATION STRUCTURE, MESQUITE, 2

195 AUTH ROWE J. S., SCOTTER G. W.
DATE 1973.
TITL FIRE IN THE BOREAL FOREST.
PUBL QUARTERNARY RES. 3:444-464.
ANNO FAUNAL SUCCESSION FOLLOWS PLANT SUCCESSION. FIRE IS IMPORTANT FOR MAINTAINING SOIL CHEMICAL PROPERTIES, VEGETATIONAL COMPOSITION, AND ANIMAL POPULATIONS, THROUGH THE MOSAIC OF HABITATS CREATED.
KEYS FIRE, POST-FIRE SUCCESSION, MOSAIC, LARGE MAMMALS, SMALL MAMMALS, PREDATORS, SNOWSHOE HARE, MARTEN, RED SQUIRREL, BEAVER, 2, WILDFIRE

196 AUTH SAIGO B. W.
DATE 1969.
TITL THE RELATIONSHIP OF NON-RECOVERED RODENT CACHES TO NATURAL REGENERATION OF PONDEROSA PINE.
PUBL M.S. THESIS, OREGON STATE UNIV., CORVALLIS. 98P.
ANNO SMALL MAMMAL SEED CACHES THOUGHT TO BE RESPONSIBLE FOR ONE-HALF OF PONDEROSA PINE REGENERATION. THIS IS MOST IMPORTANT IN AREAS DISTURBED BY ROAD CLEARING, LOGGING AND FIRE. GERMINATING SEED CLUMPS PROVIDE FOOD FOR OREGON JUNCOS AND OTHER ANIMALS. LITERATURE REVIEW ON BENEFICIAL EFFECTS OF SMALL MAMMALS ON REFORESTATION.
KEYS SMALL MAMMALS, FOOD HABITS, PONDEROSA PINE, BIRDS, GOLDEN-MANTLED GROUND SQUIRREL, YELLOW-PINE CHIPMUNK, DEER MOUSE, OREGON JUNCO, LOGGING, WILDFIRE, OREGON, LITERATURE REVIEW, 2

197 AUTH SAMPSON A. W.
DATE 1944.
TITL PLANT SUCCESSION ON BURNED CHAPARRAL LANDS IN NORTHERN CALIFORNIA.
PUBL CALIF. AGRIC. EXP. STN. BULL. 685.
ANNO FIRE KILLS MANY SMALL MAMMALS ESPECIALLY THOSE THAT LIVE IN TREES OR BRUSH. REDUCTION OF SURFACE DWELLING SMALL MAMMALS IS TEMPORARY AND THE INCREASED FOOD SUPPLY AFTER FIRE CAUSES AN INCREASE IN THEIR NUMBERS. MOST PREDATORS ARE MOBILE ENOUGH TO ESCAPE MOST FIRES.
KEYS SMALL MAMMALS, PREDATORS, LARGE MAMMALS, BIRDS, FIRE, FOOD HABITS, POPULATION DENSITY, MORTALITY, 2, CHAPARRAL, CALIFORNIA

198 AUTH SCHEFFER T. H.
DATE 1945.
TITL BURROW ASSOCIATIONS OF SMALL MAMMALS.
PUBL MURRELET 26(2)24-26.
ANNO NOTES ON KINDS OF SMALL MAMMALS TRAPPED IN MOLE BURROWS.
KEYS SMALL MAMMALS, PREDATORS, PACIFIC NORTHWEST, HABITAT, REPTILES, WEASEL, MOLES, MICE, POCKET GOPHERS, BULL SNAKE, 3

199 AUTH SCOTTER G. W.
DATE 1964.
TITL EFFECTS OF FOREST FIRES ON THE WINTER RANGE OF BARREN-GROUND CARIBOU IN NORTHERN SASKATCHEWAN.
PUBL WILDL. MANAGE. BULL. SERIES 1(18). CAN. WILDLIFE SERV., OTTAWA.
ANNO SNOWSHOE HARE AND BEAVER BENEFITTED FROM POST-FIRE SUCCESSION. RED SQUIRRELS WERE ONLY FOUND IN STANDS OLDER THAN 50 YEARS. FIRE DESTROYED MARTEN HABITAT.
KEYS SMALL MAMMALS, BIRDS, LARGE MAMMALS, POST-FIRE SUCCESSION, MARTEN, PREDATORS, RED SQUIRREL, SNOWSHOE HARE, SASKATCHEWAN,

BLACK SPRUCE, BEAVER, FIRE, 2

200 AUTH SETON E. T.
DATE 1929.
TITL LIVES OF GAME ANIMALS.
PUBL VOL. II, PART 2. DOUBLEDAY, DORAN AND CO., INC. NEW YORK. 746P.
ANNO FIRE CAUSES THE DISAPPEARANCE OF MARTEN.
KEYS MARTEN, FIRE, PREDATORS

201 AUTH SHORT H. L., MCCULLOCH C. Y.
DATE 1977.
TITL MANAGING PINYON-JUNIPER RANGES FOR WILDLIFE.
PUBL USDA FOR. SERV. GEN. TECH. REP. RM-47, 10P. ROCKY MT. FOR. AND RANGE EXP. STN. FORT COLLINS, COLO.
ANNO DESCRIBES PINYON-JUNIPER HABITATS AND WILDLIFE. DISCUSSES MANAGEMENT PROCEDURES TO BENEFIT WILDLIFE.
KEYS SMALL MAMMALS, LARGE MAMMALS, BIRDS, REPTILES, PINYON-JUNIPER, FOOD HABITS, SOUTHWEST, HABITAT MANAGEMENT, PREDATORS, GRAZING, HERBICIDE, PRESCRIBED FIRE, 3

202 AUTH SIMS H. P., BUCKNER C. H.
DATE 1973.
TITL THE EFFECTS OF CLEARCUTTING AND BURNING OF PINUS BANKSIANA FORESTS ON THE POPULATIONS OF SMALL MAMMALS IN SOUTHEASTERN MANITOBA.
PUBL AMER. MIDL. NAT. 90(1):228-231.
ANNO THE TOTAL POPULATION OF SMALL MAMMALS WAS REDUCED AFTER BURNING, BUT FOLLOWED BY A RAPID REESTABLISHMENT OF A LARGE POPULATION OF DEER MICE WHICH WERE CONSIDERED A HAZARD TO DIRECT SEEDING ON JACK PINE SITES IN MANITOBA.
KEYS SMALL MAMMALS, JACK PINE, MANITOBA, FOOD HABITS, DEER MOUSE, CLEARCUT, SLASH FIRE, 2

203 AUTH SOUTIERE E. C.
DATE 1978.
TITL THE EFFECTS OF TIMBER HARVESTING ON THE MARTEN.
PUBL PH.D. DISSERTATION. UNIV. OF MAINE, ORONO. 87P.
KEYS PREDATORS, MARTEN, LOGGING, MAINE, 2

204 AUTH SOUTIERE E. C.
DATE 1979.
TITL EFFECTS OF TIMBER HARVESTING ON MARTEN IN MAINE.
PUBL J. WILDL. MANAGE. 43(4):850-860.
ANNO SELECTIVE TIMBER HARVESTING IS COMPATIBLE WITH THE PRESERVATION OF MARTEN HABITAT. TIMBER HARVESTING DOES NOT LIMIT MARTEN FOOD. CLEARCUTS ARE POOR MARTEN HABITAT FOR THE FIRST FIFTEEN YEARS.
KEYS PREDATORS, MARTEN, MAINE, MEADOW VOLE, SMALL MAMMALS, PREDATION, CLEARCUT, SELECTIVE CUT, BIRDS, MIXED CONIFER-HARDWOOD, RED-BACKED VOLES, HABITAT, 1, SPRUCE-FIR

205 AUTH SPENCER D. A.
DATE 1955.
TITL THE EFFECTS OF RODENTS ON REFORESTATION.
PUBL PROC. SOC. AM. FORESTERS MEETING, 1955:125-128.
ANNO THIRTEEN ACRE SLASH BURN CONTAINED 50% FEWER SMALL MAMMALS THAN ADJACENT UNBURNED AREA DURING 6 DAYS IMMEDIATELY AFTER THE FIRE. THERE IS A PROGRESSIVE SHIFT IN THE TYPES OF RODENT DAMAGE AT DIFFERENT STAGES OF SUCCESSION.

KEYS SMALL MAMMALS, SLASH FIRE, POPULATION DENSITY, LOGGING, PACIFIC NORTHWEST, 3, SLASH FIRE

206 AUTH STICKEL L. F.
DATE 1946.
TITL THE SOURCE OF ANIMALS MOVING INTO A DEPOPULATED AREA.
PUBL J. MAMMAL. 27(4):301-307.
ANNO STUDIED THE INVASION OF WHITE-FOOTED MICE FROM ESTABLISHED HOME RANGES TO A CENTRAL AREA WHERE MICE WERE BEING REMOVED BY SNAPTRAPPING.
KEYS SMALL MAMMALS, WHITE-FOOTED MOUSE, MIGRATION, MARYLAND, 2

207 AUTH STODDARD H. L.
DATE 1961.
TITL THE USE OF FIRE ON SOUTHEASTERN GAME LANDS.
PUBL IN THE COOPERATIVE QUAIL STUDY ASSOC. MAY 1, 1931 - MAY 1, 1943. P. 47-63. H. L. STODDARD, H. L. BEADEL AND E. V. KOMAREK. MISC. PUBL. NO. 1. TALL TIMBERS PLANTATION.
ANNO FIRE FOR QUAIL MANAGEMENT ALSO DESTROYS COVER NECESSARY FOR COTTON RATS. POISONING AND TRAPPING RATS IS NOT NECESSARY WHEN FIRE IS USED.
KEYS COTTON RAT, FIRE, POPULATION DENSITY, SOUTHEAST, 3, BIRDS, QUAIL, SMALL MAMMALS

208 AUTH STOUT J., FARRIS A. L., WRIGHT V. L.
DATE 1971.
TITL SMALL MAMMAL POPULATIONS OF AN AREA IN NORTHERN IDAHO SEVERELY BURNED IN 1967.
PUBL NORTHWEST SCI. 45(4):219-226.
ANNO AUTHORS DID NOT DOCUMENT UNUSUAL DENSITIES OF SMALL MAMMALS ON BURN. RODENTS ON BURN WERE EATING SHRUB BARK.
KEYS SMALL MAMMALS, DEER MOUSE, VOLES, POPULATION DENSITY, IDAHO, FOOD HABITS, POST-FIRE SUCCESSION, WILDFIRE, 2

209 AUTH SULLIVAN T. P.
DATE 1979.
TITL REPOPULATION OF CLEAR-CUT HABITAT AND CONIFER SEED PREDATION BY DEER MICE.
PUBL J. WILDL. MANAGE. 43(4):861-871.
ANNO MICE CONTINUE TO INVADE RECENT CUT-OVER AREAS AND CONSUME SEED REGARDLESS OF CONTROL METHODS. SUGGESTS USE OF ALTERNATIVE FOODS TO REDUCE CONIFER SEED CONSUMPTION.
KEYS SMALL MAMMALS, CLEARCUT, DEER MOUSE, BRITISH COLUMBIA, DOUGLAS-FIR, SEED, POISONS, MIGRATION, 1

210 AUTH SUNQUIST M. E.
DATE 1967.
TITL EFFECTS OF FIRE ON RACCOON BEHAVIOR.
PUBL J. MAMMAL. 48(4):673-674.
ANNO MOVEMENTS OF A FAMILY OF RADIO-COLLARED RACCOONS WERE FOLLOWED 4 DAYS BEFORE AND 4 DAYS AFTER A FIRE WITHIN THEIR HOME RANGE. THE FIRE DID NOT SIGNIFICANTLY AFFECT THE AMOUNT OF TIME THE ANIMALS SPENT IN THE AREA BURNED.
KEYS SMALL MAMMALS, RACCOON, PRESCRIBED FIRE, SAVANNA, MINNESOTA, 2

211 AUTH TERRILL H. V., MARSHALL W. H.
DATE 1946.
TITL USING DEN BOXES TO BOOST SQUIRREL CROP.
PUBL MISSOURI CONSERV. 7:4-5.

ANNO SQUIRRELS DID NOT OCCUPY BURNED AREAS BECAUSE OF LACK OF NEST SITES.
KEYS SMALL MAMMALS, SQUIRRELS, FIRE, HABITAT, 2

212 AUTH TESTER J. R.
DATE 1965.
TITL EFFECTS OF A CONTROLLED BURN ON SMALL MAMMALS IN A MINNESOTA OAK SAVANNA.
PUBL AM. MIDL. NAT. 74(1):240-243.
ANNO AN OAK SAVANNA WAS RETRAPPED 35 DAYS AFTER A FAST HOT CONTROLLED BURN. THE NUMBER OF DEER MICE INCREASED FROM 4 TO 49 AND THE NUMBER OF RED-BACKED VOLES FROM 9 TO 13. SUGGESTS VOLES NOT AS AFFECTED BY HABITAT CHANGES CAUSED BY FIRE IN A SAVANNA, AS IN CONIFER SLASH.
KEYS SMALL MAMMALS, DEER MOUSE, RED-BACKED VOLES, OAK-SAVANNA, MORTALITY, POPULATION DENSITY, MINNESOTA, PRESCRIBED FIRE, 2

213 AUTH TESTER J. R., MARSHALL W. H.
DATE 1962.
TITL MINNESOTA PRAIRIE MANAGEMENT TECHNIQUES AND THEIR WILDLIFE IMPLICATIONS.
PUBL TRANS. NORTH AM. WILDL. NAT. RESOUR. CONF. 27:267-287.
ANNO MEADOW VOLE INCREASED WITH INCREASING LITTER AFTER FIRE, WHILE DEER MICE DECREASED.
KEYS SMALL MAMMALS, GRASSLAND, MINNESOTA, WILDFIRE, MEADOW VOLE, DEER MOUSE, POPULATION DENSITY, SPRING BURN, FALL BURN, GRAZING, MOWING, BIRDS, 2

214 AUTH TEVIS L. JR.
DATE 1953.
TITL STOMACH CONTENTS OF CHIPMUNKS AND MANTLED SQUIRRELS IN NORTHEASTERN CALIFORNIA.
PUBL J. MAMMAL. 34:316-324.
ANNO HYPOGEOUS FUNGI ARE THE MOST IMPORTANT FOOD OF CHIPMUNKS AND MANTLED SQUIRRELS IN THE COMMERCIAL TIMBER BELT OF NORTHEASTERN CALIFORNIA. SEEDS, LEAVES, FLOWERS, FRUITS, ROOTS, ARTHROPODS, AND MEAT WERE ALSO EATEN. CONCLUDES SMALL MAMMALS THAT ARE HARMFUL AT ONE TIME AND PLACE MAY BE BENEFICIAL AT ANOTHER TIME OR PLACE.
KEYS SMALL MAMMALS, CHIPMUNKS, GOLDEN-MANTLED GROUND SQUIRREL, FOOD HABITS, CALIFORNIA, 2, DOUGLAS-FIR

215 AUTH TEVIS L. JR.
DATE 1956.
TITL EFFECT OF A SLASH BURN ON FOREST MICE.
PUBL J. WILDL. MANAGE. 20(4):405-409.
ANNO EXPERIMENT TO SEE IF SLASH FIRE COULD BE USED TO CONTROL SEED EATING MICE. MOST MICE IN SLASH WERE KILLED BY THE FIRE. AS SOON AS THE ASH SURFACE WAS HARDENED BY RAIN THERE WAS A REINVASION OF MORE MICE THAN ORIGINALLY INHABITED THE SLASH.
KEYS SMALL MAMMALS, WHITE-FOOTED MOUSE, CHIPMUNKS, WOODRATS, SHREWS, MORTALITY, MIGRATION, SOIL SURFACE, DOUGLAS-FIR, CALIFORNIA, POPULATION DENSITY, CLEARCUT, SLASH FIRE, 1

216 AUTH TEVIS L. JR.
DATE 1956.
TITL INVASION OF A LOGGED AREA BY GOLDEN-MANTLED SQUIRRELS.
PUBL J. MAMMAL. 37(2):291-292.

ANNO GOLDEN-MANTLED SQUIRRELS MIGRATED FROM AN ISOLATED RIDGE WHERE A POPULATION WAS ESTABLISHED, THROUGH VIRGIN DOUGLAS-FIR TO ESTABLISH POPULATIONS IN NEWLY LOGGED AREAS. SQUIRRELS' SEED EATING HABITS REPRESENTED A THREAT TO REFORESTATION. POPULATION INCREASED IN SPITE OF POISONING.
KEYS SMALL MAMMALS, GOLDEN-MANTLED GROUND SQUIRREL, LOGGING, DOUGLAS-FIR, CALIFORNIA, WHITE FIR, FOOD HABITS, SEED, MIGRATION, 1

217 AUTH TEVIS L. JR.
DATE 1956.
TITL POCKET GOPHERS AND SEEDLINGS OF RED FIR.
PUBL ECOLOGY 37(2):379-381.
ANNO IDAHO FESCUE HAD PREVENTED SPREAD OF CONIFERS. OVERGRAZING CAUSED DISTRUCTION OF TURF AND MULTIPLICATION OF BULBOUS PLANTS. POCKET GOPHERS RESPONDED BY INCREASING. GROUND CHURNED BY POCKET GOPHERS PRODUCED AN IDEAL SEED BED FOR CONIFERS. IN 1951 A BUMPER CROP OF RED FIR CONES PRODUCED MANY SEEDLINGS. THERE WAS ABUNDANT SURVIVAL OF SEEDLINGS ON BARE GROUND AWAY FROM RODENTS.
KEYS SMALL MAMMALS, POCKET GOPHERS, GRAZING, FOOD HABITS, SEED, RED FIR, IDAHO FESCUE, CALIFORNIA, PREDATORS, COYOTE, 2

218 AUTH TEVIS L. JR.
DATE 1956.
TITL RESPONSES OF SMALL MAMMAL POPULATIONS TO LOGGING DOUGLAS-FIR.
PUBL J. MAMMAL. 37(2)189-196.
ANNO LOGGING CAUSES AN INCREASE IN THE NUMBERS OF TOWNSEND CHIPMUNKS, DUSKY-FOOTED WOOD RATS, WHITE-FOOTED AND BIG-EARED MICE, DIGGER SQUIRRELS, CHICKAREES, GRAY SQUIRRELS, AND BUSH RABBITS. TROWBRIDGE SHREWS, RED-BACKED MICE, FLYING SQUIRRELS AND SHREW-MOLES DECREASE. WHITE-FOOTED MICE AND TOWNSEND'S CHIPMUNKS BECOME MOST NUMEROUS AND ARE RESPONSIBLE FOR MOST OF THE SEED DESTRUCTION.
KEYS SMALL MAMMALS, MORTALITY, DOUGLAS-FIR, LOGGING, SLASH FIRE, FOOD HABITS, SEED, CALIFORNIA, MIGRATION, TOWNSEND'S CHIPMUNK, WHITE-FOOTED MOUSE, PINON MOUSE, CALIFORNIA GROUND SQUIRREL, DUSKY-FOOTED WOOD RAT, GRAY SQUIRREL, FLYING SQUIRRELS, DOUGLAS' SQUIRREL, BRUSH RABBIT, TROWBRIDGE SHREW, RED-BACKED VOLES, SHREW-MOLE, 2, POPULATION DENSITY

219 AUTH TRAPPE J. M., MASER C.
DATE 1977.
TITL ECTOMYCORRHIZAL FUNGI: INTERACTIONS OF MUSHROOM AND TRUFFLES WITH BEASTS AND TREES.
PUBL IN MUSHROOMS AND MAN--AN INTERDISCIPLINARY APPROACH TO MYCOLOGY. P. 163-180. A. B. WALTERS, ED. LINN-BENTON COMMUNITY COLLEGE, ALBANY, ORE.
ANNO SMALL MAMMALS, FORESTS, AND MYCORRHIZAL FUNGI HAVE EVOLVED TOGETHER AND ARE MUTUALLY DEPENDANT. SMALL MAMMALS ARE THE PRIMARY DISPERSAL AGENT FOR HYPOGEOUS FUNGI.
KEYS SMALL MAMMALS, FOOD HABITS, MYCORRHIZAL FUNGI, 2

220 AUTH TRUETT J. C.
DATE 1979.
TITL OBSERVATIONS OF COYOTE PREDATION ON MULE DEER FAWNS IN ARIZONA.
PUBL J. WILDL. MANAGE. 43(4):956-958.
ANNO DESCRIPTIONS OF COYOTE ATTACKS ON MULE DEER FAWNS AND DEFENSE OF FAWNS BY DOES.

KEYS PREDATORS, COYOTE, MULE DEER, ARIZONA, PREDATION, 2

221 AUTH TRYON C. A. JR.
DATE 1947.
TITL THE BIOLOGY OF THE POCKET GOPHER (THOMOMYS TALPOIDES) IN MONTANA.
PUBL MONT. STATE COLL. AGRIC. EXP. STN. BULL. 448. 33P.
ANNO LIFE HISTORY AND IMPORTANCE OF THE POCKET GOPHER AS A BURROWING ANIMAL IN WESTERN MOUNTAINS.
KEYS SMALL MAMMALS, POCKET GOPHERS, MONTANA, HABITAT, FOOD HABITS, 3

222 AUTH TURNER G. T., HANSEN R. M., REID V. H., TIETJEN H. P., WARD A. L.
DATE 1977.
TITL POCKET GOPHERS AND COLORADO RANGE LANDS.
PUBL BULLETIN 5545, COLO. STATE UNIV. EXP. STN., FT. COLLINS, COLO.
ANNO A COMPLETE LIFE HISTORY OF POCKET GOPHERS. INCLUDES SECTION ON CONTROL.
KEYS SMALL MAMMALS, POCKET GOPHERS, COLORADO, HABITAT, FOOD HABITS, POISONS, HERBICIDE, 2

223 AUTH USDA
DATE 1978.
TITL SPECIES LIST BIRDS, MAMMALS, FISH, REPTILES, AND AMPHIBIANS FOR THE FOREST SERVICE INCLUDING SEPARATE LISTS FOR IDAHO, MONTANA AND NORTH DAKOTA.
PUBL USDA FOR. SERV., NORTHERN REGION, MISSOULA, MONT., R1-78-002 82P.
ANNO SPECIES LISTS FOR EACH STATE IN THE NORTHERN REGION.
KEYS SMALL MAMMALS, LARGE MAMMALS, BIRDS, FISH, REPTILES, AMPHIBIANS, MONTANA, IDAHO, NORTH DAKOTA, 3

224 AUTH VIERECK L. A., DYRNESS C. T. (EDS.)
DATE 1979.
TITL ECOLOGICAL EFFECTS OF THE WICKERSHAM DOME FIRE NEAR FAIRBANKS, ALASKA.
PUBL USDA FOR. SERV. GEN. TECH. REP. PNW-90, 71P. PAC. NORTHWEST RANGE AND EXP. STN., PORTLAND, ORE.
ANNO RED-BACKED VOLES WERE REDUCED AFTER THE FIRE, AND DID NOT OVER WINTER IN THE BURN UNTIL 3 YEARS LATER. THE RELATIVELY RARE TUNDRA VOLE BECAME NUMEROUS ON THE BURNED AREA 3 YEARS AFTER THE FIRE. SNOWSHOE HARE POPULATIONS WERE HIGH (6 HARES PER HECTARE) AND CONSUMED LARGE QUANTITIES OF WILLOW SPROUTS AND CHARRED BARK DURING THE FALL AND WINTER AFTER THE FIRE.
KEYS SMALL MAMMALS, RED-BACKED VOLES, TUNDRA VOLE, SNOWSHOE HARE, WILDFIRE, ALASKA, POST-FIRE SUCCESSION, BLACK SPRUCE, 2, HABITAT

225 AUTH VOGL R. J.
DATE 1967.
TITL CONTROLLED BURNING FOR WILDLIFE IN WISCONSIN.
PUBL TALL TIMBERS FIRE ECOL. CONF. 6:47-96.
ANNO HISTORICAL ACCOUNT OF THE IMPORTANCE OF FIRE IN MAINTAINING GRASSLANDS IN WISCONSIN AND THE SIGNIFICANCE OF PRAIRIE AND SAVANNA HABITATS TO WILDLIFE.
KEYS BIRDS, MULE DEER, SMALL MAMMALS, DIRECT EFFECTS, POST-FIRE SUCCESSION, MORTALITY, HABITAT, WISCONSIN, PRESCRIBED FIRE, 2

226 AUTH VOGL R. J.
DATE 1973.
TITL EFFECTS OF FIRE ON THE PLANTS AND ANIMALS OF A FLORIDA WETLAND.
PUBL AM. MIDL. NAT. 89:334-347.
ANNO NO BIRD OR MAMMAL INJURY WAS OBSERVED DUE TO FIRE. SOME AMPHIBIANS AND REPTILES WERE KILLED. FOUR MONTHS AFTER THE FIRE MAMMAL POPULATIONS OF BURNED AND UNBURNED AREAS APPEARED SIMILAR.
KEYS BIRDS, REPTILES, MORTALITY, AMPHIBIANS, SMALL MAMMALS, FLORIDA, WETLAND, PRESCRIBED FIRE, 2

227 AUTH VOLLAND L. A.
DATE 1974.
TITL RELATION OF POCKET GOPHERS TO PLANT COMMUNITIES IN THE PINE REGION OF CENTRAL OREGON.
PUBL IN WILDLIFE AND FOREST MANAGEMENT IN THE PACIFIC NORTHWEST. P. 149-166. H. C. BLACK, ED. PROC. 1973 SYMP. ORE. STATE UNIV., CORVALLIS.
ANNO GOPHERS PREFER LODGEPOLE FORESTS WITH LUSH STANDS OF LONG-STOLEN SEDGE AND/OR FORBS. WHEN LOGGING OR BURNING OCCURS ADJACENT TO THESE COMMUNITIES, INVASION BY GOPHERS CAN BE EXPECTED.
KEYS SMALL MAMMALS, POCKET GOPHERS, OREGON, PONDEROSA PINE, LODGEPOLE PINE, HABITAT, 1

228 AUTH VREELAND H., LUGASKI T., VREELAND P.
DATE 1979.
TITL INTEGRATED ECOLOGY OF THE GREAT BASIN. PART III. A PRELIMINARY ANALYSIS OF NOWARK SUMMIT, EUREKA COUNTY, NEVADA.
PUBL NORTHWEST SCI. 53(3):180-189.
ANNO VEGETATIONAL COMMUNITY IS A GOOD INDICATOR OF ANIMAL SPECIES AND THEIR POPULATION SIZES. DESCRIBES HABITAT PREFERENCES OF DIFFERENT SMALL MAMMAL SPECIES.
KEYS SMALL MAMMALS, GREAT BASIN, SAGEBRUSH-GRASS, GRAZING, HABITAT, LEAST CHIPMUNK, DEER MOUSE, GREAT BASIN POCKET MOUSE, MONTANE VOLE, BUSHY-TAILED WOODRAT, 2

229 AUTH WANGERSKY P. J., CUNNINGHAM W. J.
DATE 1957.
TITL TIME LAG IN PREY-PREDATOR POPULATION MODELS.
PUBL ECOLOGY 38(1):136-139.
ANNO AFTER DEFINING THE PARAMETERS OF PREY AND PREDATOR POPULATIONS, POPULATION EQUATIONS ARE MOST EASILY HANDLED BY APPROXIMATION ON AN ANALOG COMPUTER.
KEYS PREDATION, 3

230 AUTH WECKWERTH R. P., HAWLEY V. D.
DATE 1962.
TITL MARTEN FOOD HABITS AND POPULATION FLUCTUATIONS IN MONTANA.
PUBL J. WILDL. MANAGE. 26(1):55-74.
ANNO FLUCTUATIONS IN PREY SPECIES NUMBERS AFFECTED THE NUMBER OF MARTEN IN THIS AREA. FOOD ITEMS WERE GENERALLY USED IN PROPORTION TO THEIR ABUNDANCE EXCEPT WHEN AFFECTED BY AVAILABILITY OR PREFERENCE BY MARTEN. MICROTUS AND CLETHRIONOMYS WERE PREFERRED MAMMALIAN FOODS.
KEYS MARTEN, FOOD HABITS, MONTANA, PREDATORS, POPULATION DENSITY, SMALL MAMMALS, 1

231 AUTH WEST S. D.
DATE 1974.
TITL POST-BURN POPULATION RESPONSE OF THE NORTHERN RED-BACKED VOLE, CLETHRIONOMYS RUTILUS IN INTERIOR ALASKA.
PUBL M.S. THESIS, UNIV. ALASKA, FAIRBANKS. 66P.
KEYS SMALL MAMMALS, RED-BACKED VOLES, ALASKA, POST-FIRE SUCCESSION, WILDFIRE, 2

232 AUTH WEST S. D.
DATE 1979.
TITL HABITAT RESPONSES OF MICROTENE RODENTS TO CENTRAL ALASKAN FOREST SUCCESSION.
PUBL PH.D. THESIS. UNIV. CALIF., BERKELEY. 115P.
KEYS SMALL MAMMALS, VOLES, ALASKA, PLANT SUCCESSION, HABITAT, 2

233 AUTH WILLIAMS O.
DATE 1955.
TITL DISTRIBUTION OF MICE AND SHREWS IN A COLORADO MONTANE FOREST.
PUBL J. MAMMAL. 36(2):221-231.
ANNO GIVES HABITAT TYPES IN WHICH VARIOUS SMALL MAMMALS WERE TRAPPED.
KEYS SMALL MAMMALS, SHREWS, WHITE-FOOTED MOUSE, RED-BACKED VOLES, ROCKY MOUNTAIN PHENACOMYS, MEADOW VOLE, WESTERN JUMPING MOUSE, HABITAT, COLORADO, 3

234 AUTH WILLIAMS O.
DATE 1959.
TITL FOOD HABITS OF THE DEER MOUSE.
PUBL J. MAMMAL. 40(3):415-419.
ANNO SEEDS MADE UP TWO-THIRDS TO THREE-FOURTHS OF THE MATERIAL FOUND IN THE STOMACHS OF DEER MICE COLLECTED IN WYOMING AND COLORADO. ONE-TENTH TO ONE-FIFTH OF THE MATERIAL CONSISTED OF INSECT AND ARACHNID REMAINS.
KEYS SMALL MAMMALS, DEER MOUSE, FOOD HABITS, COLORADO, MONTANA, 2

235 AUTH WOLFF J. O.
DATE 1978.
TITL FOOD HABITS OF SNOWSHOE HARES IN INTERIOR ALASKA.
PUBL J. WILDL. MANAGE. 42(1):148-153.
ANNO DESCRIBES FOOD HABITS OF SNOWSHOE HARES IN ALASKA.
KEYS SNOWSHOE HARE, FOOD HABITS, ALASKA, SMALL MAMMALS, 3

236 AUTH YEAGER L. E.
DATE 1950.
TITL IMPLICATIONS OF SOME HARVEST AND HABITAT FACTORS ON PINE MARTEN MANAGEMENT.
PUBL TRANS. NORTH AM. WILDL. CONF. 15:319-334.
ANNO THE IMMEDIATE EFFECT OF FIRE ON MARTEN POPULATIONS IS DESTRUCTIVE. LOGGING AND GRAZING ARE SLOWLY CONSUMING MARTEN HABITAT. RECOMMENDS NOVEMBER-DECEMBER TRAPPING SEASONS BECAUSE MORE MALES ARE TRAPPED DURING THIS TIME AND COULD BE REMOVED AS SURPLUS POPULATION, YIELDS OF HIGH QUALITY PELTS, AND BETTER CONDITIONS FOR TRAPPING.
KEYS MARTEN, HABITAT, FIRE, LOGGING, GRAZING, TRAPPING, 2

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237  AUTH  YEAGER L. W.
     DATE  1961.
     TITL  CLASSIFICATION OF NORTH AMERICAN MAMMALS AND BIRDS ACCORDING TO
           FOREST HABITAT PREFERENCE.
     PUBL  J. FOR. 59(9):671-674.
     ANNO  CLASSIFICATION OF BIRDS AND MAMMALS BY FOREST HABITAT
           PREFERENCE.
     KEYS  BIRDS, SMALL MAMMALS, LARGE MAMMALS, HABITAT, 2
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Physiological Research on Adventitious Shoot Development in Aspen Roots

George A. Schier

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THE AUTHOR

GEORGE A. SCHIER, research plant physiologist stationed at the Forestry Sciences Laboratory in Logan, Utah, joined the Intermountain Station staff in 1969. He holds the bachelor of science degree in forestry from the University of New Hampshire, the master of forestry degree from Yale University, and the doctoral degree in woody plant physiology from the University of Michigan. As a member of the multifunctional research work unit "Ecology and Management of Aspen Lands in the West," his research focuses on the vegetative regeneration of aspen.

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RESEARCH SUMMARY

Adventitious shoots (suckers) from the roots of aspen (*Populus tremuloides* Michx.) originate from newly initiated meristems, preexisting primordia, or suppressed buds. Development of suckers on aspen roots is suppressed by auxin transported from aerial parts. Interference with the auxin supply by cutting, girdling, burning, or herbicide treatments decreases the auxin concentration in the roots enabling suckers to be initiated, or if their growth was suppressed by auxin, to continue to grow. Suckers are probably initiated by cytokinins, which are synthesized in root tips. High cytokinin-auxin ratios favor shoot initiation; low ratios inhibit it. Gibberellins are important in shoot elongation. Any interference with their biosynthesis or action could affect sucker growth. Development of suckers is suppressed on roots of dormant aspen by high levels of dormancy-causing inhibitors such as abscisic acid. Carbohydrate reserves in the parent root supply the energy necessary for bud initiation and shoot outgrowth. An elongating sucker remains totally dependent upon root reserves until it emerges at the soil surface and can carry on photosynthesis.

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Physiological Research on Adventitious Shoot Development in Aspen Roots

George A. Schier

INTRODUCTION

Aspen (*Populus tremuloides* Michx.) occurs in clones of a few to thousands of genetically identical individuals. Clonal growth results because aspen has the ability to regenerate vegetatively by adventitious shoots, often called suckers, that arise on its long ropelike lateral roots. Because of short-lived seed and demanding seedbed requirements, aspen seedling establishment is not common. Aspen has been able to remain a widespread and abundant species because of its root suckering ability.

There is probably no other plant species in which single genotypes so completely dominate large areas of land. Although most aspen clones are less than a hectare in size, clones over 10 hectares are not uncommon in some areas. Kemperman and Barnes (1976) delineated a clone in southern Utah that was 43 hectares in size and contained about 47,000 ramets. In areas where the climate enables seedlings to become established, such as the Lake States, clones tend to be smaller. Clone size is probably highly correlated with clone age. However, no method exists by which the age of individual clones can be determined. Possibly some large western clones may have become established during Pliocene or Miocene times, enlarging themselves asexually through many generations of ramets.

Reviewed here are the results of my research on the physiological mechanisms involved in the development of adventitious shoots in aspen roots. Included are the results of some studies that had not been previously published. The data are on file at the Forestry Sciences Laboratory in Logan, Utah.

ORIGIN OF SUCKERS

In many woody plants that have the ability to regenerate by root suckers, the suckers originate from preexisting suppressed buds that arise during normal development of primary tissue systems (Schier and Campbell 1976). The buds are embedded in the periderm and their vascular traces extend to the primary xylem of the stele. Unlike most other species, root suckers in aspen do not originate at a specific time in the ontogeny of a root. Instead, they develop from meristems that appear to be initiated near the cork cambium at various times during secondary growth (Brown 1935; Sandberg 1951; Schier 1973b). These meristems may develop into buds and then elongate into shoots, but frequently growth is arrested at the primordial stage or after the formation of a bud. Development may not be continuous because the physiological requirements for the initiation of an apical meristem are different from that for its growth and extension (Butenko 1964; Schier 1973a).

Thousands of suppressed shoot primordia can be found on the roots of most aspen clones. They occur as small mounds protruding from the cork cambium. The primordia can be seen without magnification by peeling off the cork (Schier 1973b). Primordia occur in various stages of ontogeny: from those that are essentially small masses of meristematic cells with no tissue differentiation, to those in which procambium and protoxylem elements are differentiated. The length of time an adventitious meristem can remain in the primordial stage is unknown.

Although suckers do arise from suppressed buds, buds are not as important a source of suckers as are newly initiated meristems or preexisting primordia (Sandberg 1951; Schier 1973b). Sandberg (1951) observed that suppressed buds on roots often remained inhibited, while numerous newly initiated meristems on the same root developed into suckers. Suckers that originated from suppressed buds elongated much less vigorously than those that were recently initiated.

INTERCLONAL AND INTRACLONAL VARIATION

In the relative capacity of aspen clones to produce suckers, large clonal differences have been found when suckers are propagated from root cuttings under controlled environmental conditions (table 1) (Schier 1974). The magnitude of the differences among clones varies with the date of collection because the seasonal trend in sucker production shows considerable clonal variation. The number of suckers produced by a clone is probably determined by the balance of food reserves and hormonal growth regulators in the roots. Genotype probably has a large influence on suckering capacity, but nongenetic factors such as clone history, stem age, and environmental variables could also be major contributors. Some clones, in spite of a high suckering capacity, produce few viable suckers because their excised roots are highly susceptible to decay (table 2). The season when roots are collected has a significant effect on the incidence of decay during sucker propagation.

Within an aspen clone exists considerable variation in suckering capacity among lateral roots (table 3) (Schier 1978a). Differences among lateral roots are probably caused by differences in the physiological condition of the roots (such as, water content, hormone levels and ratios, concentration of nutrients), which in turn is caused by microclimate variability and root position in the clonal root system. Temperature, an important microclimate element, varies with soil depth and exposure to radiation. Physiological condition as controlled by root position depends upon proximity and attachment to trees of various ages and vigor. This position will determine the quantity of photosynthates and auxins and other growth regulators translocated to a particular root.

There is no evidence of a gradient in suckering capacity in a segmented root; that is, cuttings from a root do not show a significant change in suckering capacity with increasing distance from the stem (Schier 1978a). This indicates that distance from the parent tree or root age are not factors regulating suckering within lateral roots.

Table 1.—Mean suckering ability of root cuttings (10 × 1 to 2 cm) from 20 Utah aspen clones collected on 3 different dates after 6 weeks in moist vermiculite (greenhouse temperatures 15-25° C)

	Suckers (>5 mm) per segment				Height of tallest sucker (mm)			
Clone	5/76	7/75	9/74	Average	5/76	7/75	9/74	Average
1	10.5	6.0	9.2	8.57	29	26	31	28.7
2	4.9	2.7	6.0	4.53	39	33	34	35.3
3	5.9	6.1	4.5	5.50	37	30	33	33.3
4	2.4	5.5	5.0	4.30	46	41	34	40.3
5	4.4	10.7	3.4	6.17	35	30	24	29.7
6	7.3	8.7	7.3	7.77	47	42	44	44.3
7	6.9	7.5	7.1	7.17	38	32	44	38.0
8	14.0	21.4	13.3	16.23	28	26	32	28.7
9	6.7	12.7	21.4	13.60	36	31	37	34.7
10	4.5	3.6	16.5	8.20	32	30	35	32.3
11	5.9	3.4	5.0	4.77	29	21	30	26.7
12	8.4	8.2	9.3	8.63	39	27	42	36.0
13	2.2	2.1	4.1	2.80	37	22	30	29.7
14	6.5	15.3	9.5	10.43	46	27	44	39.0
15	5.0	5.6	3.9	4.83	35	36	49	40.0
16	11.1	15.4	21.2	15.90	47	30	36	37.7
17	7.9	8.3	14.6	10.27	38	23	32	31.0
18	6.2	9.8	4.6	6.87	28	30	44	34.0
19	6.0	6.0	6.5	6.17	36	29	35	33.3
20	6.1	3.1	4.6	4.60	32	30	35	32.3
Mean	6.64	8.1	8.85	7.87	36.7	29.8	36.2	34.2

Table 2.—Percentage of aspen root segments (10 × 1 to 2 cm) showing signs of decay after 6-weeks in moist vermiculite in a growth chamber (25°/15° C, 12/12 h temperature regimen)

Collection date	Clone										Mean
	1	2	3	4	5	6	7	8	9	10	
June	48	72	55	5	8	0	0	2	5	0	20
August	45	75	35	2	12	0	0	0	12	2	19
October	12	48	20	5	0	0	5	0	0	2	9
Mean	35	65	37	4	7	0	2	1	6	2	16

Table 3.—Mean suckering ability of root segments (10 cm) excised from 27 randomly selected lateral roots (diameter, 1 to 2 cm; length, 51 to 412 cm) from a single aspen clone after 6-weeks in moist vermiculite (greenhouse temperatures, 15-25° C)

Lateral root	Suckers (>5 mm) per segment	Height of tallest sucker (mm)	Lateral root	Suckers (>5 mm) per segment	Height of tallest sucker (mm)
1	6.3	38	15	6.1	42
2	3.7	48	16	4.8	37
3	11.6	51	17	8.3	42
4	8.6	41	18	11.6	51
5	7.8	45	19	.8	17
6	4.0	35	20	9.6	45
7	11.2	41	21	.6	12
8	13.0	42	22	7.8	38
9	10.2	30	23	10.7	51
10	17.2	40	24	3.4	48
11	15.9	49	25	12.3	35
12	4.9	42	26	6.8	49
13	5.2	43	27	22.7	44
14	4.1	37			
			Mean	8.56	42.0

ROLE OF GROWTH REGULATORS

Adventitious shoot development on aspen roots is stimulated by cutting stems. We are dealing with a form of apical dominance, a term traditionally used to describe the control exerted by the shoot apex over lateral buds. Substantial evidence shows that sucker development is suppressed by auxin transported from aerial parts (Farmer 1962; Eliasson 1971a, 1971b, 1972; Schier 1973d, 1975). Less is known about the factors that induce shoot initiation, although research in other plants and the culture of plantlets in aspen callus indicate that cytokinins synthesized in roots are likely to be involved (Peterson 1975; Winton 1968; Wolter 1968). High cytokinin-auxin ratios probably favor shoot initiation and low ratios inhibit it. Other hormones studied because of their possible role in sucker development are abscisic acid, ethylene, and the gibberellins.

Auxins

I used three approaches to determine if root suckering is inhibited by auxin:

1. Determine the effect of indole-3-acetic acid (IAA), a naturally occurring auxin, on suckering from root cuttings.
2. Determine if there is a relationship between sucker production and levels of endogenous auxin.
3. Determine if suckering can be stimulated by treating roots with an antiauxin.

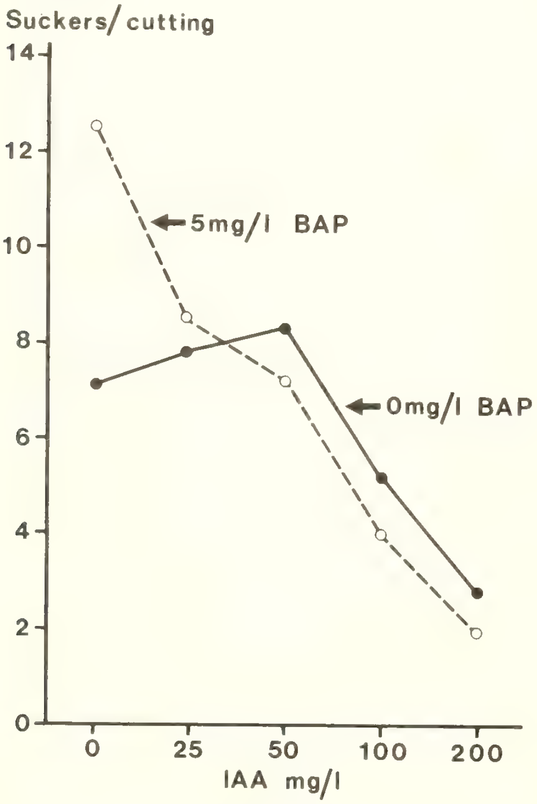

Figure 1.—Effect of five concentrations of IAA with and without 5 mg/l BAP on suckering from aspen root cuttings.

The inhibitory effect of exogenous auxin on sucker production was shown by treating root segments with a range of concentrations of IAA with and without 5 mg/l of the cytokinin 6-benzylamina-purine (BAP) (fig. 1).[1] By itself, IAA became inhibitory at concentrations over 50 mg/l. BAP alone increased sucker production over that of the controls by 78 percent. Its promotive effects were entirely eliminated by adding as little as 25 mg/l IAA. At high IAA concentrations, BAP appeared to interact synergistically with IAA, increasing its inhibitory action, but there was no significant difference between the paired treatments.

The inhibitory action of auxin on sucker development was also tested by treating root segments with a single concentration of IAA (100 mg/l) in combination with varying concentrations of BAP (fig. 2). BAP alone stimulated sucker production showing its greatest promotion at 10 mg/l. Addition of IAA reduced sucker production below that of the controls and eliminated any promotive effects of BAP.

Eliasson (1971b), studying suckering in *Populus tremula*, found that removal of growing shoot parts from young plants reduced the concentration of auxin in the roots. He also found that auxin levels in root cuttings decreased during the first 24 hours after excision due to its rapid destruction, and was low during the period of sucker development (Eliasson 1971a). Transport of auxin to roots must be continuous if inhibitory levels of auxin are to be maintained. However, even after much auxin has been inactivated, there probably is still enough remaining in root cuttings to affect sucker production (Schier 1973d).

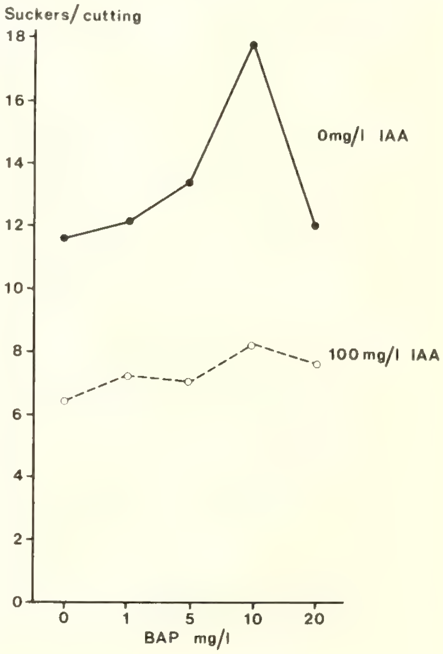

Figure 2.—Effect of five concentrations of BAP with and without 100 mg/l IAA on suckering from aspen root cuttings.

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[1] The standard procedure for testing the effects of growth regulators on sucker production was to soak root cuttings (10 cm in length, 1 to 2 cm in diameter) for 24 h in aqueous solutions of the chemicals and then to plant them horizontally in moist vermiculite. After 6 weeks, the number of shoots over 5 mm in height were determined.

This was indicated in a study of the relationship between the seasonal variation in sucker production from root cuttings of three aspen clones and concentrations of auxin in the roots when collected (fig. 3). A decrease in sucker numbers was correlated with an increase in auxin concentration (fig. 4). A regression developed by combining the data of the three clones was significant. After the variance due to clones was accounted for, 72 percent of the variation in sucker numbers was associated with auxin content. The fewest suckers were produced in June during the flush in shoot growth when the greatest quantity of auxin was found in the roots.

Thus it appears that there is enough auxin in root cuttings to affect initiation and early development of suckers. Auxin inactivation probably causes a change from a high level of inhibition in the intact plant to a low level in root segments.

The possibility exists that auxin may not be destroyed, but converted to indoleacetyl aspartic acid (personal communication, Kenneth V. Thimann, University of California, Santa Cruz). Later, under modified circumstances, this peptide may be slowly hydrolyzed to provide a source of auxin in root segments.

Even though a good correlation existed between seasonal variation in sucker production and concentration of endogenous auxin, a causal relationship was not shown. Therefore, the hypothesis that auxin in excised roots at the time of collection inhibits subsequent sucker development, was tested by treating root segments with an apparent antiauxin, α—(*p*-chlorophenoxy)isobutyric acid (CPIBA). This was an attempt to reduce auxin inhibition and thereby increase sucker production (Schier 1975). Cuttings were collected in the spring when endogenous auxin levels were highest. The antiauxin significantly increased sucker production (fig. 5). Number of suckers on cuttings treated with 25 mg/l CPIBA was twice the number produced by controls. Thus, CPIBA apparently had relieved auxin inhibition.

Additional evidence that auxin in excised roots affects suckering was indicated by the polarity shown in sucker production in root sections (Schier 1978a). A gradient was found in the number of suckers arising along uncut 50 cm root sections decreasing from the proximal to the distal ends (fig. 6). Polarity in roots is usually attributed to the movement of endogenous auxin to the distal ends (Robinson and Schwabe 1977). When the root sections were cut into 10 cm segments, a polar gradient in sucker numbers failed to develop along the section because auxin could not be redistributed. However, there was a gradient in each individual 10 cm segment: 64 percent of the suckers arising on the proximal halves and only 36 percent on the distal halves.

Once suckers develop on roots, transport of auxin from elongating shoots may increase auxin levels in the parent roots and inhibit further sucker initiation (Schier 1972).

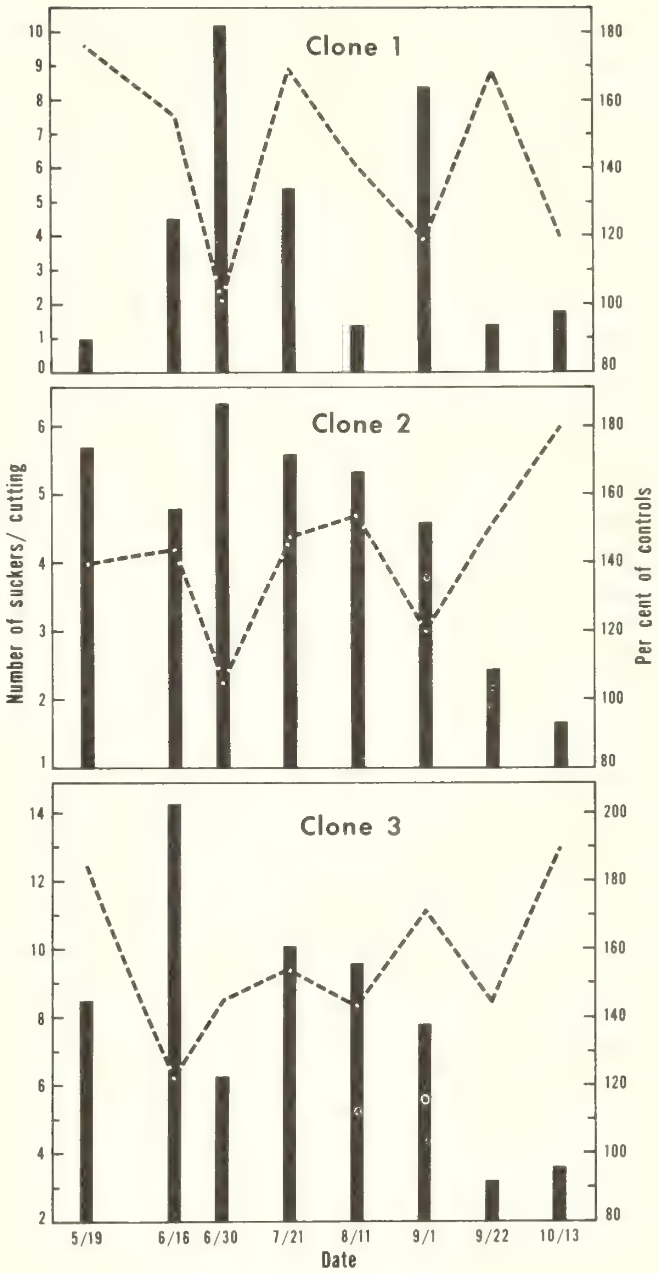

*Figure 3.—Seasonal variation in auxin content of roots at time of collection (solid vertical bars) and average number of suckers subsequently produced from root cuttings (dashed horizontal lines) for three aspen clones. Auxin-like activity was measured by the average elongation in percentage of controls of **Avena** internode sections, which were incubated with the IAA zone of chromatograms (R_f 0.2-0.3) of the acid ether fraction of methanol extract from root bark.*

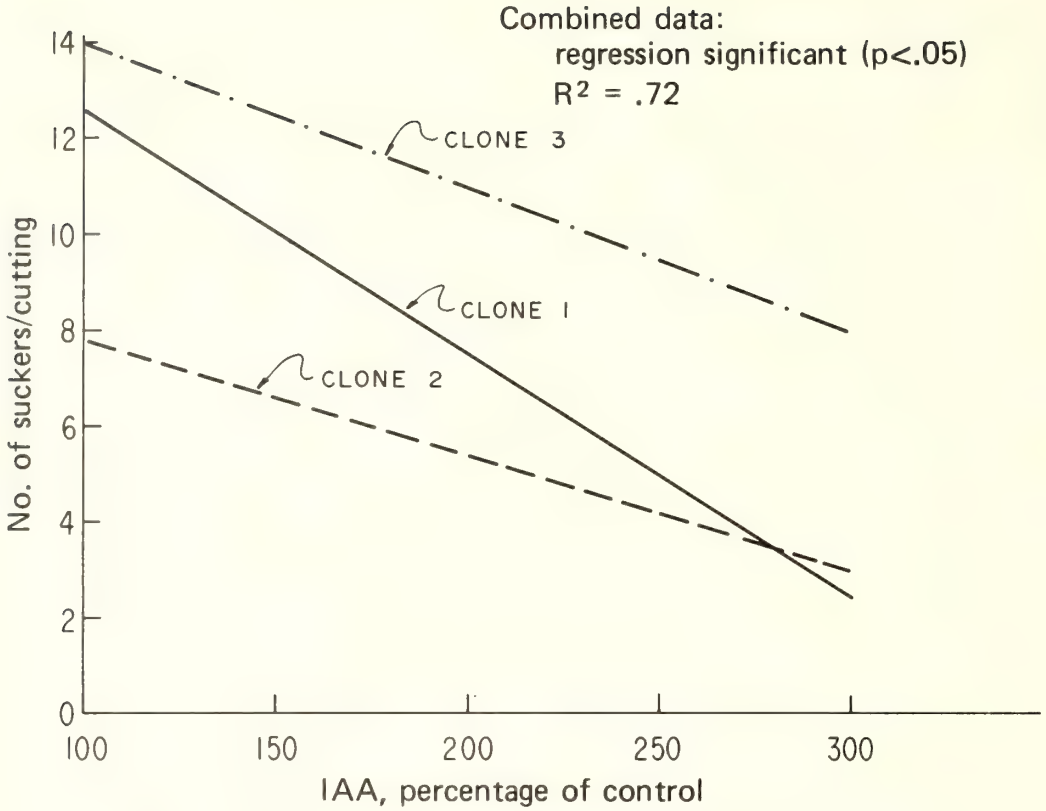

Figure 4.—Relationship between the concentration of auxin in root bark of three aspen clones when collected and number of suckers subsequently produced by root cuttings.

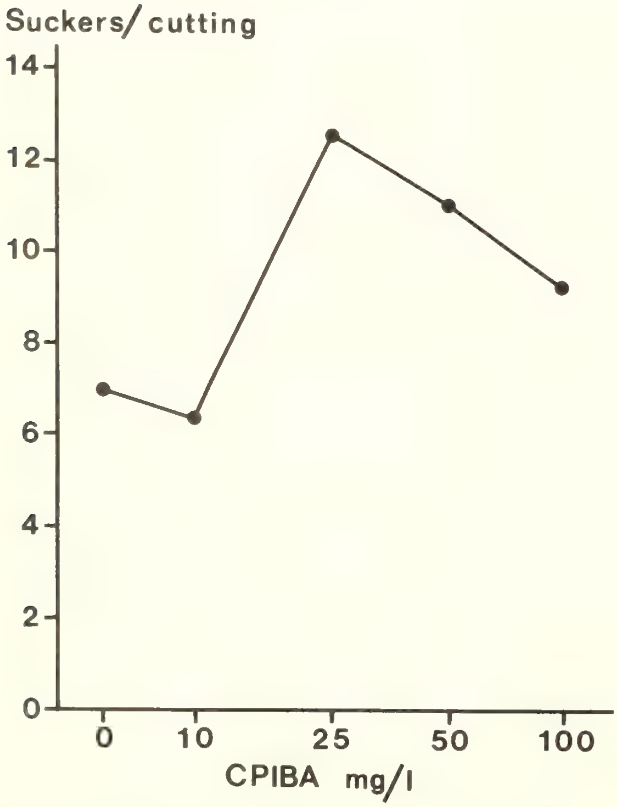

Figure 5.—Effects of the antiauxin, α–(p-chlorophenoxy)isobutyric acid (CPIBA), on sucker production by aspen root cuttings.

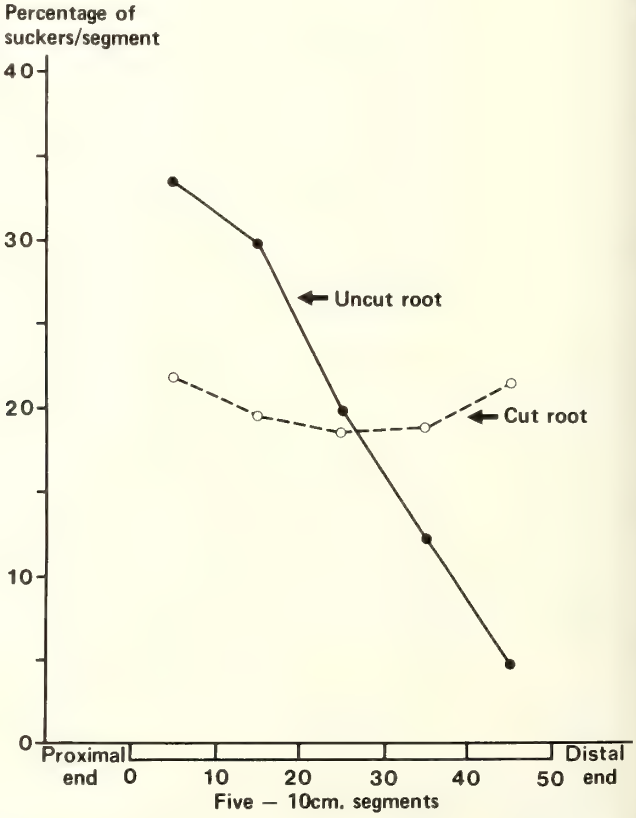

Figure 6.—Distribution of suckers along cut and uncut 50-cm sections of aspen roots.

This is supported by experiments in which continuous shoot removal increased sucker production from root cuttings.

The relatively large number of suckers that appear to arise regularly in many undisturbed aspen clones indicates that apical dominance is not absolute (Schier 1975; Schier and Smith 1979). This is not surprising when one considers the distance IAA, a relatively unstable compound, must be transported from its source in developing buds and young leaves to the roots where it brings about its morphogenetic effects. Apical dominance weakens as auxin goes down the stem due to immobilization, destruction, and age effects (Thimann 1977).

During normal seasonal tree growth, there are periods when apical dominance is weak enough for suckering to occur. For example, in spring before bud burst and translocation of auxin to the roots, temperatures are often high enough for sucker initiation and growth (Schier 1978b). Sucker formation is inhibited after the leaf buds have opened and apical dominance is reasserted.

Cytokinins

Considerable evidence in the literature shows that cytokinins have an important role in shoot initiation in roots (Peterson 1975) and in the release of buds from apical dominance (Thimann 1977). Several cytokinin-like compounds have been isolated from a poplar hybrid (Hewett and Wareing 1973). The promotive effects of BAP on sucker production by root cuttings are shown in figures 1 and 2. However, in numerous experiments in which the effects of natural and synthetic cytokinins were tested, I failed to get a response to cytokinin treatments. The reason might be that endogenous cytokinins in the roots were at optimum levels for sucker formation at the time of treatment. One of my early experiments supports this conclusion (Schier 1970). I treated root cuttings with kinetin, dissolving it in 0.05 N HCl (pH 1.2). This acidic solvent expectedly was highly inhibitory, but it did lead to some interesting results (fig. 7). Relative to the distilled water control, the solvent alone reduced sucker production by 84 percent. However, this inhibition was overcome by the addition of kinetin. A logical interpretation of these results is that the solvent caused a breakdown of endogenous cytokinins essential for sucker development, and the need for a cytokinin was replaced by kinetin.

I also haven't had much success in stimulating adventitious shoot development in intact and decapitated hydroponically grown aspen by treatment with cytokinins (Schier 1977). This was due to the toxicity of relatively low concentrations. Nutrient solutions containing 1.6 mg/l 6-benzylamino-purine (BAP) caused death of half of the plants and leaf-yellowing and -browning in others. All plants growing in nutrient solutions containing 6.4 mg/l BAP were dead within 7 days of adding the cytokinin to the solution. Severe drought symptoms and mortality were caused by root-dieback. At lower concentrations of BAP, drought symptoms were not observed, but water absorption by the roots was reduced as indicated by a decrease in transpiration. Collins and Kerrigan (1974) reported that cytokinins reduce the water permeability of plant roots. Root buds were found in only a few plants treated with 0.4 mg/l BAP. These were confined to parts of roots near the base of the stem.

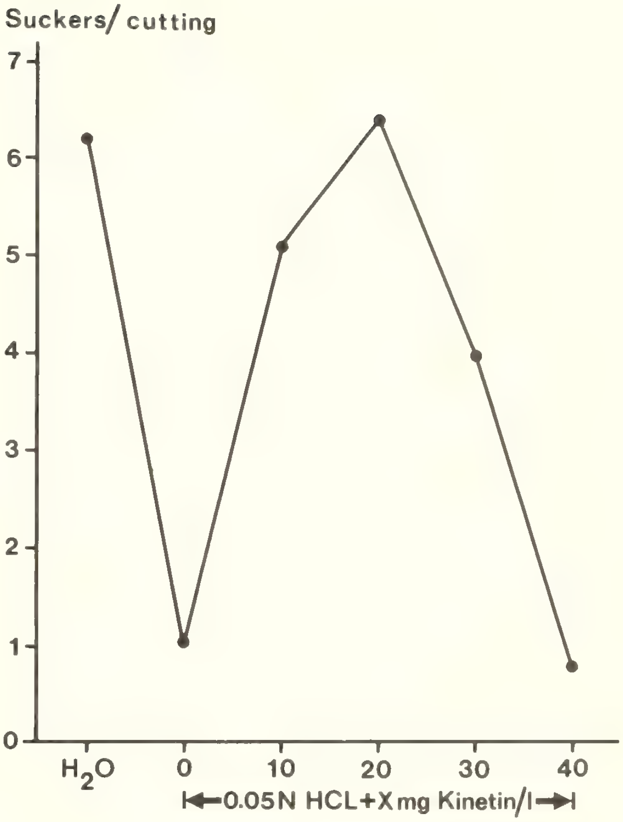

Figure 7,—Effects of kinetin on the inhibiting effect of HCl on aspen root suckering.

Gibberellins

Schier and others (1974) found at least three gibberellin-like compounds in the methanolic extract of aspen roots. The main peak of biological activity cochromatographed with gibberellic acid (GA_3) on silica gel partition columns (fig. 8). A mass peak with the same retention time as GA_3 was present on two gas-liquid chromatography columns. Concentration of the gibberellins in roots of mature trees varied with the season of the year. Levels remained high after leaf fall at which time auxins could no longer be detected.

The effect of GA_3 on suckering from excised roots depends on the stage of development of the adventitious shoots when the roots are treated (Schier 1973a). If the shoots arise primarily from newly initiated meristems (clone 8, fig. 9), GA_3 reduces sucker production because it inhibits initiation and division of the first shoot primordium cells (Heide 1969; Murashige 1964). As a primordium increases in cell number, GA_3 shows progressively less inhibition of bud formation. At some stage in bud development, GA_3 will stimulate emergence of established shoot primordia. Therefore, GA_3 treatment will promote sucker production from root segments having large well-developed primordia (clone 13, fig. 9).

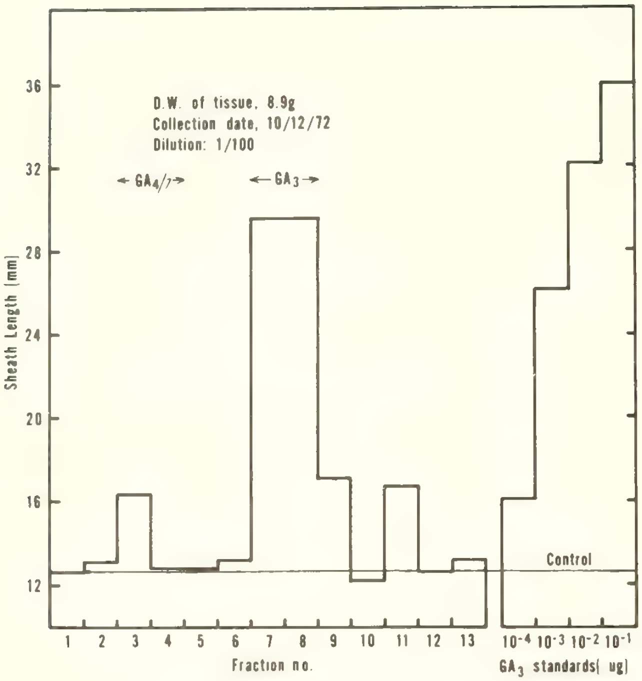

Figure 8.—Dwarf rice (cv. Tan-ginbozu) microdrop assay of a silica gel partition column chromatogram of a purified methanol extract of aspen roots.

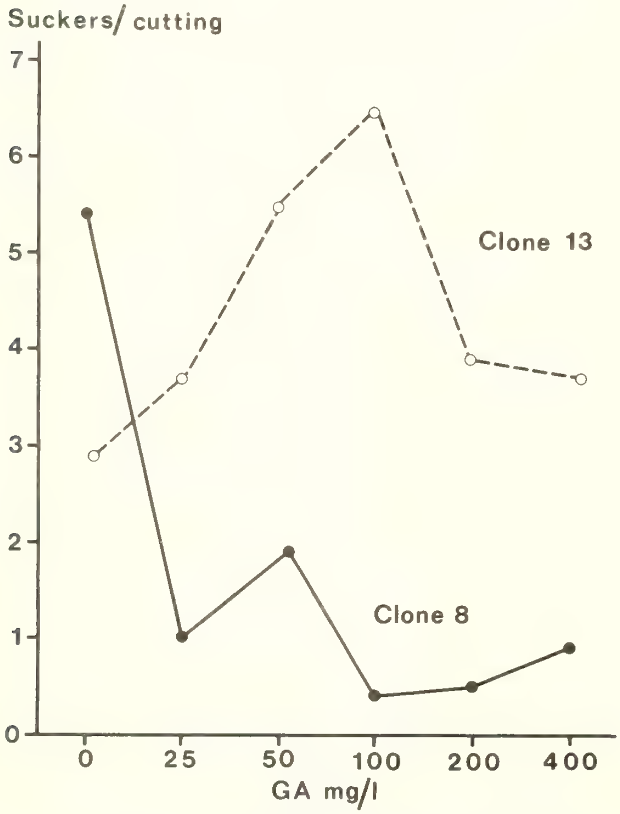

Figure 9.—Effects of gibberellic acid (GA_3) on sucker production by aspen root cuttings with (clone 13) and without (clone 8) well-developed preexisting shoot primordia.

The role of endogenous gibberellin in sucker development was studied by treating roots having numerous preexisting shoot primordia with A-rest (a substituted primidine, formerly EL-531), the trade name for a growth regulator manufactured by Elanco Products Co. known to inhibit the role of gibberellin in internode elongation (Leopold 1971). A-rest inhibited sucker production suggesting that endogenous gibberellins are important in sucker growth (fig. 10).

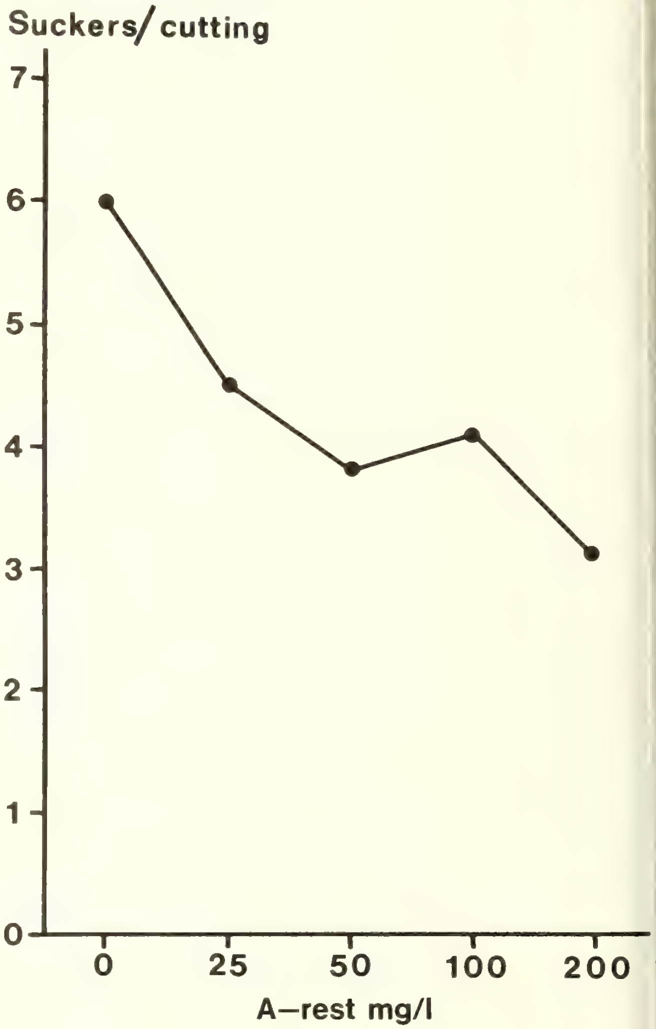

Figure 10.—Effects of A-Rest (formerly EL-531) on sucker production by aspen root cuttings.

Abscisic Acid

Although abscisic acid (ABA) is a well-known growth inhibitor, Heide (1968) found that it promoted bud initiation in detached leaves of Begonia. Therefore, I was interested in the effect ABA would have on sucker development (Schier 1973c). If ABA was found to inhibitory, it would be interesting to test the ability of GA_3 to reverse ABA inhibition. Root cuttings were treated with ABA at the start of the experiment. At 26 days the cuttings were lifted and half treated with 100 mg/l GA_3, half with distilled water. Then they were replanted. All cuttings were examined at the end of 40 days.

ABA inhibited sucker production (fig. 11). Following ABA, treatment with GA_3 resulted in partial reversal of the ABA inhibition. A growth retardation of about 30 percent remained that could not be reversed by application of GA_3. Since GA_3 is known to be inhibitory during the early stages of sucker development (Schier 1973a), the 30 percent retardation may represent the relative number of primordia that ABA prevented from developing to a stage at which they could be promoted rather than inhibited by GA_3.

ABA may have a role in inhibiting sucker growth in dormant aspen. When young aspen were decapitated after going dormant in late summer, buds formed on the roots but they did not elongate until the following spring (Schier 1978b). Regulation of dormancy generally seems to be controlled by a balance between endogenous inhibitors, such as ABA, and growth promoting substances, especially gibberellins. Dormancy is broken by low winter temperatures, which lowers the inhibitor: growth-promoter ratio.

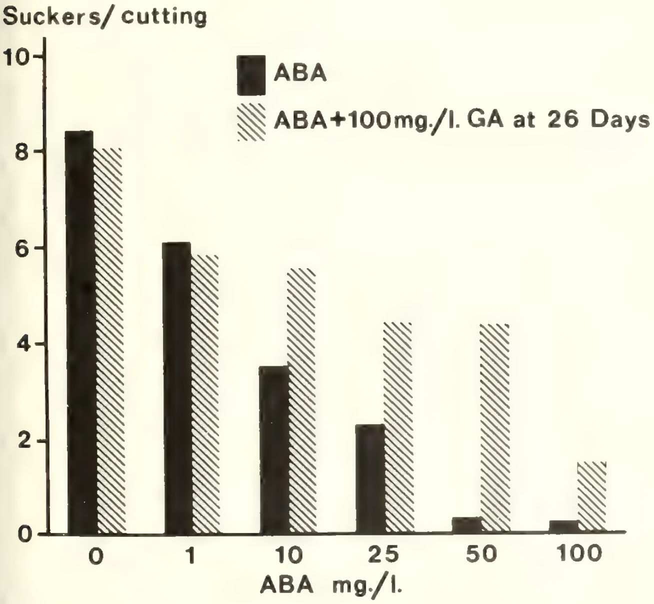

Figure 11.—Effects of cis-trans ABA and GA_3 on sucker production by aspen root cuttings. Cuttings were treated with six concentrations of ABA and then planted. After 26 days, the cuttings were lifted, treated with 100 mg/l GA_3, and replanted. Fourteen days later sucker counts were made on all cuttings.

Ethylene

Ehtylene affects a wide range of developmental processes in plants, including abscission, apical dominance, adventitious bud development, rooting, and senescence. Auxin-induced ethylene production could account for the inhibitory action of applied auxin (Burg 1973; Abeles 1973). Therefore, I thought it worthwhile to test the effect of this hormone on sucker development.

Ethephon [(2-chlorethyl) phosphonic acid] is an effective ethylene generator and was a convenient agent for bringing about ethylene responses in aspen roots. The effect of ethephon on adventitious shoot development was similar on cuttings collected in June and August from the same clone (fig. 12) (Schier and Campbell 1978). At 100 mg/l, ethephon significantly increased shoot production relative to controls. Further increases in concentration resulted in a decrease in sucker production.

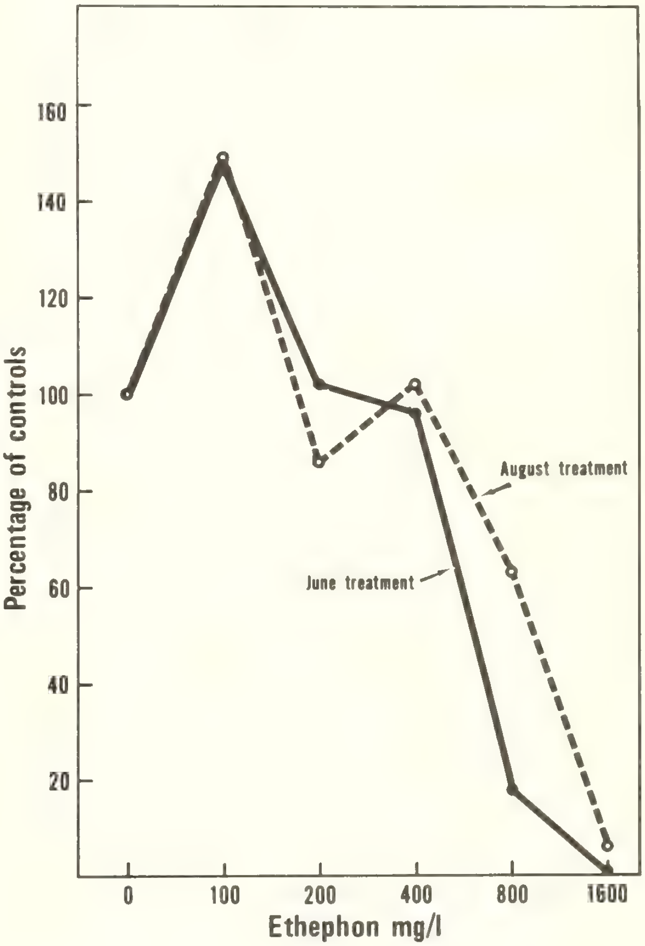

Figure 12.—Effect of ethephon (Amchem's Ethrel formulation 68-240) on sucker production by aspen root cuttings collected in June and August 1974. The mean number of suckers in each treatment is expressed as the percentage of suckers on control cuttings. Mean number of suckers per cutting in controls: June, 8.48 and August, 5.08.

Suppression of suckering by high concentrations of ethephon may have resulted because the ethylene generated is an inhibitor of cell division. However, the gas also has the ability to reduce inhibition caused by endogenous auxin. Thus, there was a potential for growth promotion after the ethylene dissipated. Apparently, this is why ethephon at 100 mg/l stimulated shoot production. At the higher concentrations, ethylene probably remained at inhibitory levels during the entire propagation period.

ROLE OF FOOD RESERVES

In addition to growth regulators, the energy supplied by carbohydrates and other reserves is necessary for sucker initiation and growth. Suckers arise from parent roots that are as deep as 30 cm in the soil. Elongating suckers will remain dependent on reserves until they can emerge from the soil, develop leaves, and carry on photosynthesis.

Carbohydrates

In a study of the role of carbohydrate reserves in roots of Alaskan and Utah aspen at various seasons on initial sucker growth, suckers were propagated in darkness in order to simulate light conditions in soil (Schier and Zasada 1973). A seasonal variation in percentage of total nonstructural carbohydrates (TNC) was found in aspen roots (fig. 13). The trend was similar in both areas. Carbohydrate contents of the roots showed a significant relationship to both clone of origin and date of collection.

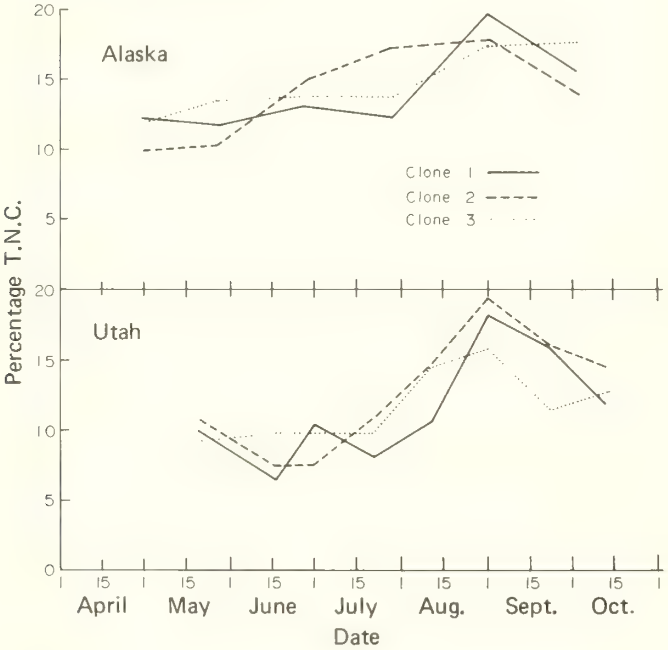

Figure 13.—Seasonal variation in percentage of total nonstructural carbohydrates (T.N.C.) in aspen roots from Utah and Alaska.

For the range in concentration of TNC in root samples, 5 to 20 mg/g dry weight, there was no correlation between sucker numbers and carbohydrate content. Numbers of suckers appear to be a function of hormone levels and ratios. However, in the additive models that were constructed from the data (fig. 14), carbohydrate reserves contributed significantly both statistically and quantitatively to sucker dry weight. As shown in figure 14A, dry weight of all suckers produced on a cutting was positively correlated with both number of suckers per cutting and percentage of total nonstructural carbohydrates. The effect of sucker numbers indicates that utilization of reserve carbohydrates is dependent upon the number of growing apices or sinks for metabolites. The larger the number of elongating shoots, the greater the capacity of sucker growth to tap the pool of reserve carbohydrates.

Figure 14B indicates that although dry weight of all suckers per cutting increased as the number of suckers became larger, dry weight of each individual sucker decreased. This is probably due to correlative inhibition and competition among suckers for a limited supply of carbohydrates.

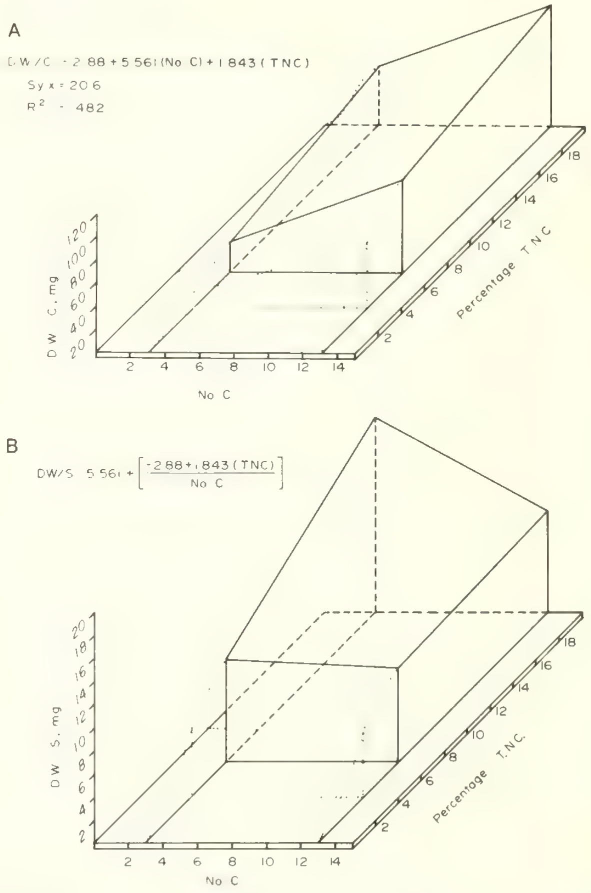

Figure 14.—Additive models in which (A) dry weight of suckers per cutting (DW/C) and (B) dry weight per sucker (DW/S) are a function of number of suckers per cutting (No/C) and percentage of total nonstructural carbohydrates (T.N.C.). The models were constructed using the combined data from each of three Utah aspen clones. Dotted lines are extrapolated.

Nitrogenous Compounds and Lipids

The role of total nitrogen and lipids (saponifiable) in aspen roots on initial development of suckers was investigated in a single clone. Neither numbers nor dry weight of suckers were correlated with the seasonal variation in concentration of these nutritional factors. Concentrations of total nitrogen and lipids were significantly related to date of collection (fig. 15).

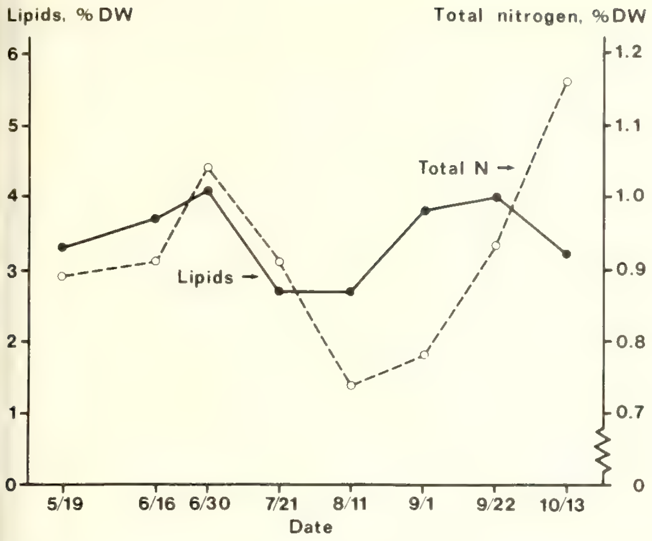

Figure 15.—Seasonal variations in concentrations of total nitrogen and saponifiable lipids in aspen roots.

Levels of lipids in aspen roots were much higher than those previously reported for tree roots (Kramer and Kozlowski 1960; Ziegler 1964). Generally, only small amounts of lipids are believed to be synthesized in roots of trees under normal conditions, with starch as the primary reserve material.

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KEYWORDS: *Populus tremuloides*, trembling aspen, adventitious shoots, root suckers, clonal variation, auxins, cytokinins, gibberellins, abscisic acid, ethylene, carbohydrate reserves, lipids, nitrogenous compounds

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Fire Costs, Losses, and Benefits:
An Economic Valuation Procedure

Robert J. Marty

Richard J. Barney

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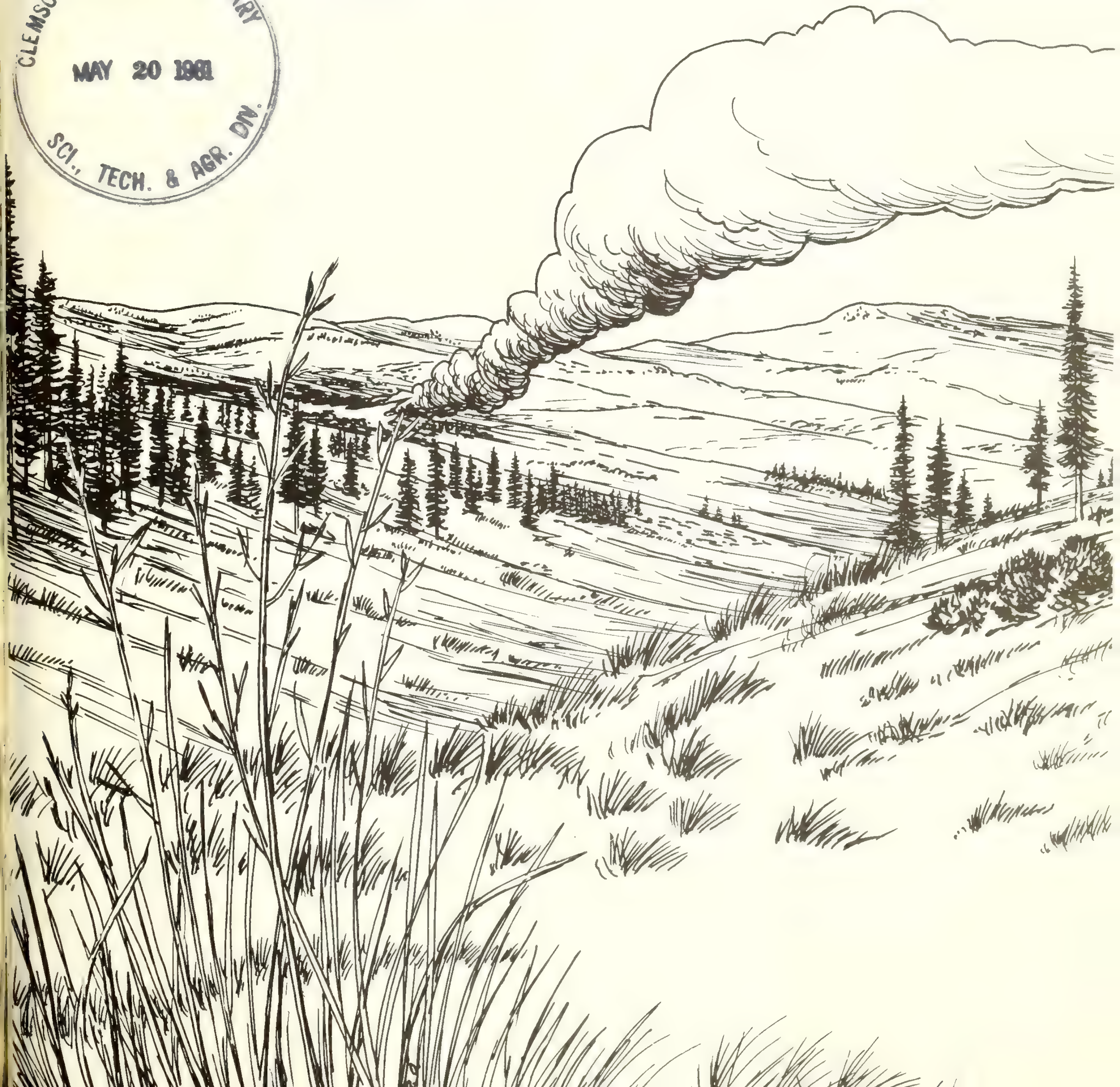

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RESEARCH SUMMARY

A guidebook has been developed to assist the fire managers and planners in estimating actual economic costs, losses, and benefits resulting from fire management activities. This guidebook was developed and tested on 12 National Forests during the 1977-79 period. The procedures were developed primarily for Forest Service use but are adaptable to other agency and individual situations. Individual fire reports provide the basic fire inputs for the process while the guidelines lead the user on a stepwise basis through an array of economic processes. The procedure is based on 10 value components. Detailed instructions have been developed and a suggested working form provided. The authors point out that continued development and improvement of this type of process is an absolute necessity if sound management decisions are to result.

PREFACE

This guidebook was prepared as a part of the Fire in Multiple-Use Management Research, Development, and Application Program carried out by the Northern Forest Fire Laboratory in Missoula, Mont. The procedures contained in this guidebook were developed and tested on 12 National Forests during the 1977-79 period.[1] It is hoped that these proposed procedures will prove both practical and helpful to fire managers.

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Fire Costs, Losses, and Benefits: An Economic Valuation Procedure

Robert J. Marty
Richard J. Barney

INTRODUCTION

This guidebook is meant to aid fire managers and fire management planners on the National Forests develop improved estimates of the actual economic costs, losses, and benefits associated with fire management. Although these procedures were developed initially for Forest Service use, they are adaptable to other management situations. Improved valuation of fire management costs, losses, and benefits is a necessary precondition to more effective fire management planning.

"The basic fire management policy on National Forest System Lands is to provide well-planned and executed fire protection and fire use programs that are cost effective and responsive to land and resource management goals and objectives and supportive"[2] of the Resources Planning Act (RPA) outputs. In order to insure that fire management programs are cost effective and responsive, it is necessary to be able to compare program cost and benefits. Changes in fire protection programs cause changes in the number, size, or severity of wildfires. Is the change in program cost consistent with the change in net losses due to wildfire? Changes in fire use programs also are to be cost effective and responsive. Does a prescription fire create enough net benefits to justify its cost?

In order to answer such questions as accurately as possible it is necessary to have good estimates of the costs, losses, and benefits associated with both wildfires and prescription fires. Fire costs, losses, and benefits vary a great deal, depending on fire location, size, intensity, fuel condition, weather condition, type of vegetative cover, and many other factors.

The individual fire report now provides for estimates of the value of resources damaged or destroyed and for acres burned by value class. A more complete estimate of fire costs, losses, and benefits is needed. Resource damage is only a part of the picture. Also to be considered are life and health losses, rehabilitation costs, beneficial impacts of fire, and other value components. The value class concept is a useful one, but it does not provide an accurate estimate of damage or loss. For example, all fires in range grassland are assigned an average loss and damage of $250 per acre. In actual fact, some range fires produce a net loss, while others provide a net benefit.

The fire valuation procedures presented in this guidebook provide a more accurate and complete estimate of fire costs, losses, and benefits. They call for postfire examination of each class C and larger wildfire and each prescription fire, leading to a summarization of costs, losses, and benefits for each. After these data have been collected for several years it will be possible to accurately estimate for each fire management area the costs, losses, and benefits which have actually been experienced for fires of different sizes occurring in various vegetative types. The new valuation data collected each year will provide an automatic updating of value estimates, as well. With these improved valuation data it will be possible to carry out more accurate comparisons of the cost and benefit associated with changes in fire management programs.

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[2] USDA Forest Service. 1978. Forest Service Manual. Title 5100 - Fire Management, 5103 Policy. Washington, D.C.

CONCEPTUAL BASIS

Valuation is the process of associating an economic value with the physical costs, losses, and resource changes that result from fire management programs. Valuation is accomplished by tracing the chain of events which occurs as the result of fire, to determine who has experienced a change in income or wealth and how large those changes are.

The Fire Valuation Model

Fire management gives rise to a chain of events which has certain economic results. Presuppression decisions and actions and actual wildfire experience and control effort lead to specific postcontrol conditions on fire sites. These physical effects, on and beyond fire sites, lead to productivity changes for the resources involved, which in turn may result in changes in resource use.

Precontrol decisions and actions determine the amount of presuppression fire management expenditure. Control itself occasions control expenditures for the Forest Service and for unreimbursed cooperators who contribute to the control effort. Fires result in other immediate losses as well, chief among which are property destruction or damage and life and health losses.

After control some wildfires give rise to the need for rehabilitation treatments and may cause changes in the productivity and thus the use of timber, forage, recreation, and other resources. Changes in use cause changes in the economic and social values that will be derived from fire management areas.

The fire valuation model has 10 value components. Each is briefly described below, and its valuation basis is identified. Detailed procedures for estimating each component are presented in the following section. These procedures call for an "Individual Fire Valuation Report" to be prepared for class C and larger wildfires and for all prescription fires. This fire valuation report records the physical effects of the fire, along with certain economic information which forms the basis for estimating economic impacts.

1. **Presuppression cost**.--Included here are presuppression costs both for the Forest Service and cooperating fire control agencies unreimbursed by the Forest Service. Forest level costs are prorated to fire management areas. An equal share of fire management area presuppression cost is assigned to each fire. The valuation basis is actual expenditures and obligations. Fire management expenditures at regional and Chief's Office levels are excluded.

2. **Suppression cost**.--Actual suppression costs for fires originating within the fire management area are included in this component. Suppression costs incurred for fighting fires originating outside the fire management area are excluded. Suppression efforts contributed by other Forest Service units or cooperators are included. The suppression efforts contributed by unreimbursed cooperators are valued at Forest rates, when actual expenditures cannot be determined. The valuation basis is actual expenditures and obligations, and suppression cost is assigned to individual fires on the basis of averag suppression cost for its wildfire size class.

3. **Life and health loss**.--This component includes th cost of medical treatment for those injured or made i as the direct result of a fire and the value of work tim lost for all persons killed or injured. The valuation basi for medical treatment costs is average hospitalizatio costs outside standard metropolitan statistical areas, a reported by the American Hospital Association. Th valuation basis for work time lost is based on the averag net contribution to GNP[3] of employed persons.

4. **Property loss**.--Property loss includes damage o destruction of transportation equipment and facilities communications facilities, land improvements, productio structures and equipment, residences, recreation facilitie and structures, agricultural crops, and livestock. Th valuation basis for damaged but repairable property is th cost of the repair. For property damaged beyond repair the valuation basis is depreciated value, based on origina cost, age, and useful life. Replacement costs, an ofte suggested basis, is an overestimate of the value of partiall depreciated property.

5. **Rehabilitation cost**.--Rehabilitation treatments or fire sites and beyond when necessitated by a fire are included in this component. Costs are estimated on the basis of recent cost experience. Rehabilitation treatments undertaken by others as the result of a fire are included. The valuation basis is estimated cost as a function of acreage to be treated and current average cost per acre for similar treatments on the forest. Although these treatments may not be undertaken for several years, no attempt is made to discount in this component because the timelag usually is short.

6. **Timber effects**.--Included in this component is the value of cut timber products destroyed, together with the value of stumpage under sale contract destroyed less the value of timber salvaged from the fire site. The valuation basis for these elements is current value to the buyer for products destroyed or salvaged. In addition, this component includes an estimate of the present value of future changes in timber output caused by fire. This estimate is based on the volume of merchantable stumpage destroyed, the growth loss or gain in immature stands, current average stumpage prices, and the assumption that losses or gains will be reflected in an equal annual change in timber sales over a 100-year rotation. This estimate assumes that any timber lost or gained because of fire would eventually have found a market.

7. **Forage effects**.--This component comprises the value of forage destroyed and of the change in future forage output. The value of forage destroyed in active allotments is based on volume and current value to the buyer per AUM. The discounted value of future changes in forage output are based on current price per AUM.

8. **Recreation effects**.--Fire may influence developed site recreation, disbursed recreation, and wilderness recreation. It is assumed here that fire curtails recreational

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[3] Abbreviations and acronyms are defined in appendix I.

use of a burned area for an average of 6 months, where-pon recreational use will be resumed on the burned area r will have been relocated elsewhere. The valuation bases f this component are the 1980 RPA assessment values for ecreational use.

9. **Wildlife effects**.--Fire may either increase or ecrease the amount of hunting and fishing on burned reas and, in some cases, downstream from them. Estimates of the changes caused by fire to five different ategories of hunting and fishing are valued by using 1980 RPA assessment values.

10. **Water effects**.--Until a burned area again supports adequate vegetative cover, fires can cause increases in water yield from burned areas as well as reductions in water quality caused by increased sedimentation and other factors. Changes in water yield and water quality are valued by using 1980 RPA assessment values.

Important Attributes of the Model

Here are some important points about the fire valuation model that users should understand:

1. The model is constructed in such a way that it will provide estimates of the economic impacts of both wildfire and prescription fire. Both kinds of fire can cause costs, osses, and benefits. In wildfires, costs and losses often outweigh benefits. For prescription fires benefits should exceed costs and losses.

2. The model includes the costs and losses of and benefits to not only the Forest Service, but to fire management cooperators, and to loggers, ranchers, and recreationists as well. The means of accomplishing this are to include the cost of fire management paid for by other organizations and individuals and to value changes in timber, forage, recreation use, wildlife, and water on the basis of their value to the user, rather than from the standpoint of the receipts they generate to the Federal government. The unit values of outputs are based on current forest experience or are derived from value estimates used in the 1980 RPA assessment.

3. Although much of the economic impact of fire is concentrated in the year of occurrence, other costs, losses, and benefits crop up during subsequent years and decades. Economic impacts occurring in future years are discounted to the present, using a 5 percent or 10 percent discount factor. The 5 percent rate is recommended because it approximates the 1969-78 average interest paid on long-term Federal government debt. The 10 percent discount factor is the one currently (1979) required by Office of Management and Budget (OMB).

THE INDIVIDUAL FIRE VALUATION REPORT

A basis must exist for estimating the physical effects of fires. Not all wildfires cause damage or output change, of course. Many class A and B fires have little or no effect, but many larger fires do cause such changes. Methods for estimating change in the physical productivity of resource systems lies outside the scope of this publication. This guidebook is concerned with valuing such changes once they have been identified. During the testing of the valuation procedures, however, it became apparent that currently available records were not satisfactory in all regards for establishing physical losses and changes in resource outputs. An attempt was made to use the Individual Fire Report, Form 5100-29, as a basis. It would be possible to modify fields 41-44 of this report, which record the value of resources damaged or destroyed and area by value classes, to provide a more adequate basis for valuation. But, because of the rapid reporting time required for Form 5100-29, it seems more appropriate to recommend an additional report, an Individual Fire Valuation Report. This new report would be completed only for class C and larger fires and as sufficient time becomes available for a careful examination of the fire site. The Individual Fire Valuation Report also should be used to record the effect of prescribed fires on resource system outputs.

The report form (fig. 1) in a preliminary format and detailed instructions for completing each item follow.

Preparing the Individual Fire Valuation Report

This report is to be prepared for all class C or larger wildfires and for all prescription fires.

IDENTIFICATION ITEMS

Item 1.	**Forest**. Enter name of Forest initially responsible for action.
Item 2.	**Fire Management Area**. Enter name of fire management area within which initial ignition occurred.
Item 3.	**Fire Name**. If a wildfire, enter fire name from Form 5100-29. If a prescription fire, enter "Prescription Fire."
Item 4.	**Fire Number**. If a wildfire, enter supervisor fire number from Item 5, Form 5100-29. If a prescription fire, enter P-01, -02, -03 . . . in order by date of occurrence.
Item 5.	**Date of Fire**. From Form 5100-29 or prescription fire record.
Item 6.	**Date of Report**. Enter date report is completed.
Item 7.	**Prepared By**. Enter name of officer preparing the report.

CONTROL INFORMATION ITEMS

Item 8.	**Area Burned**. Enter from Item 36, Form 5100-29 or prescription fire record.
Item 9.	**Unreimbursed Suppression Effort**. Estimate the number of man-days of effort contributed by personnel not paid from Forest funding. Include here personnel from other Forest Service units, from State fire control agencies, and from timber harvesting companies, when no charge against Forest funding or direct reimbursement has or will be made. These unreimbursed man-days will be valued at the average cost per man-day of fire control on the Forest and included in the total cost of control.

INDIVIDUAL FIRE VALUATION REPORT

Page 1

IDENTIFICATION

1. Forest ______ 2. Fire Management Area ______

3. Fire Name ______ 4. Fire Number ______

5. Date of Fire ______ 6. Date of Report ______

7. Prepared by ______

CONTROL INFORMATION

8. Area Burned ______ 9. Unreimbursed Suppression Effort ______

DEATHS, INJURIES AND ILLNESSES

10. Name	11. Age at Death	12. Length of Hospitalization (days)

13. Worktime Lost

INDIVIDUAL FIRE VALUATION REPORT

Page 2

PROPERTY LOSS

14. Kind of Property	15. Original Cost or Cost of Repair	16. Age

REHABILITATION TREATMENTS

17. Treatment Type	18. Treatment Area (acres)	19. Treatment Cost (dollars)

Figure 1.--*Proposed form for an Individual Fire Valuation Report.*

INDIVIDUAL FIRE VALUATION REPORT

Page 3

TIMBER EFFECTS

20. Value of cut timber products destroyed ____________________ (dollars)

Stumpage under sale contract destroyed.

21. M bd.ft.________ 22. Price per M bd.ft.________________(dollars)

23. Cds. ________ 24. Price per cord ________________(dollars)

Volume of stumpage salvaged:

25. M bd.ft.________ 26. Price per M bd.ft.________________(dollars)

27. Cds. ________ 28. Price per cord ________________(dollars)

Unsalvaged merchantable stumpage destroyed:

29. M bd.ft.________ 30. Cds. ________________

Growing stock losses and gains

31. Growing stock losses: M bd.ft.____________ Cds.________

32. Growing stock gains: M bd.ft.____________ Cds.________

FORAGE EFFECTS

Volume of forage destroyed in active allotments:

33. AUM's ________________ 34. Price per AUM ________________ (dollars)

Effect of fire on future forage production:

35. Area Burned________________(acres) 36. Average annual per acre changed in forage production ________________________ (AUM's)

37. Duration of effect ________________________ (years)

INDIVIDUAL FIRE VALUATION REPORT

Page 4

RECREATION EFFECTS

Current annual use of recreation facilities within the burned area:

38. RVD's ________________

Current annual dispersed recreational use of burned area:

39. RVD's ________________

Current annual wilderness recreational use of burned area:

40. RVD's ________________

WILDLIFE EFFECTS

	41. Change in RVD's
Anadromous sport fishing	________
Other sport fishing	________
Small game and upland game bird hunting	________
Waterfowl hunting	________
Big game hunting	________

WATER EFFECTS

Increase in water yield:

42. AF ____________ 43. Duration of effect ____________________

Reduction in water quality:

44. AF ____________ 45. Duration of effect ____________________

Figure 1.--con.

INDIVIDUAL FIRE VALUATION REPORT

Page 5

OTHER EFFECTS

46. Description of effects

INDIVIDUAL FIRE VALUATION REPORT

Page 6

COST, LOSS, AND BENEFIT SUMMARY

		5% Present Values		**10% Present Values**	
		Cost or Loss	**Benefit**	**Cost or Loss**	**Benefit**
Item 47.	Presuppression cost				
Item 48.	Suppression cost				
Item 49.	Life and health loss				
Item 50.	Property loss				
Item 51.	Rehabilitation cost				
Item 52.	Timber effects				
Item 53.	Forage effects				
Item 54.	Recreation effects				
Item 55.	Wildlife effects				
Item 56.	Water effects				
	Totals	______	______	______	______
Item 57.	Net Present Values	______		______	

Figure 1.-- con.

DEATHS, INJURY, AND ILLNESS ITEMS

Item 10. **Name**. List the name of each person who died, was injured, or became ill as the result of the fire, that is, where the death, injury, or illness would not have occurred if there had been no fire. If name is unknown enter "Unknown Person." Non-Forest Service personnel are to be included.

Item 11. **Age at Death**. For persons killed as the result of the fire, enter their age at death. If unknown, enter approximate age and enclose in parentheses.

Item 12. **Length of Hospitalization**. For all persons admitted to a medical facility for treatment, enter the number of days before death or release. Enter "1 day" for those hospitalized for less than 24 hours. If person was hospitalized, but length of stay is unknown, enter "unknown." For persons not hospitalized, enter "none."

Item 13. **Worktime Lost.** For all persons injured or made ill by the fire, enter the number of days or months of worktime lost. If unknown, enter "unknown."

PROPERTY LOSS ITEMS

Item 14. **Kind of Property**. For each item of property damaged or destroyed, enter a description. Include non-Forest Service property.

Item 15. **Original Cost or Cost of Repair**. For each item of property listed in item 14 which was damaged beyond repair, enter an estimate of original cost. For agricultural crops, original cost is the cost of establishing and tending incurred before the crop was destroyed. For property that is damaged but repairable, estimate cost of repair.

Item 16. **Age**. For each item of unrepairable property listed in item 14, enter the age of the equipment or structure. For orchards, vineyards, and other perennial agricultural crops, age is the number of years since establishment.

REHABILITATION TREATMENT ITEMS

Item 17. **Treatment Type**. For each rehabilitation treatment planned, enter the type of treatment, for example tree planting, grass seeding, etc.

Item 18. **Treatment Area**. For each treatment listed in Item 17, enter the area to be treated in acres.

Item 19. **Treatment Cost**. For each item listed in item 17, enter the expected cost of treatment per acre. Base this estimate on current costs for similar treatments on the National Forest.

TIMBER EFFECTS ITEMS

Item 20. **Value of Cut Timber Products Destroyed.** Enter the value of any logs, poles, posts, and other cut timber products destroyed. If value is unavailable from owner, it may be calculated by multiplying volume of products destroyed by the sum of stumpage price plus average logging cost per M bd.ft. or cord. Stumpage prices and logging cost estimates for the sale are available from timber sales records.

Item 21. **M bd.ft.** Enter here the volume of sawtimber or other board foot measure stumpage under sale contract which has been destroyed.

Item 22. **Price Per M bd.ft.** Enter the price per thousand board feet specified in the sale contract for destroyed stumpage listed in item 21.

Item 23. **Cds**. Enter here the volume of pulpwood and other cord measure stumpage under sale contract which has been destroyed.

Item 24. **Price Per Cord**. Enter the price per cord specified in the sales contract for destroyed stumpage listed in item 23.

Item 25. **M bd.ft.** Enter here volume of sawtimber and other board measure stumpage which has been or will be sold by salvage sale.

Item 26. **Price Per M bd. ft**. Enter the price per thousand board feet for salvage stumpage listed in item 25. Obtain this price from salvage sale records, or from timber staff preparing the salvage sale.

Item 27. **Cds**. Enter here the volume of pulpwood or other cord, measure stumpage which has been or will be sold by salvage sale.

Item 28. **Price Per Cord**. Enter the price per cord for salvage stumpage listed in item 27.

Item 29. **M bd.ft.** Enter here the volume of unsalvaged merchantable sawtimber stumpage destroyed.

Item 30. **Cds**. Enter here the volume of unsalvaged merchantable pulpwood stumpage destroyed.

Item 31. **Growing Stock Losses**. To calculate growth loss due to fire in stands not of merchantable size, use the formula $\text{LOSS} = A(M \cdot Y \cdot K \cdot S)$ when

M = mean annual increment per acre at rotation
Y = age of stand at time of fire
K = percentage of stand killed by fire
S = percentage of full stocking prior to fire
A = acres affected.

The formula should be applied separately to stands differing in M, Y, K, or S and the sum of all losses should be entered in item 31.

Item 32. **Growing Stock Gains**. Prescription fires and some wildfires cause increases in mean annual increment. In these circumstances, calculate growing stock gains by using this formula:

$\text{GAIN} = A(I)\ (R-Y)$ when

A = acres affected
I = increase in per acre mean annual increment caused by the fire
R = rotation age
Y = age of stand at time of fire.

FORAGE EFFECTS ITEMS

Item 33. **AUM's**. Enter here the number of animal unit months of forage destroyed in active allotments.

Item 34. **Price per AUM**. Enter the price per animal unit month currently charged to the allotment holder. Prices are available from range allotment records.

Item 35. **Area Burned**. Enter the area of forage allotments burned.

Item 36. **Change in Forage Production**. Enter the annual per acre change in forage production anticipated as the result of fire. This change may be either positive or negative and may differ for different allotments. Calculate change separately for different situations. The range management staff may be best able to supply these estimates.

Item 37. **Duration of Effect**. Enter here the number of seasons over which the change will continue. In cases where there is a fire-caused production loss but rehabilitation is anticipated, the duration of loss cannot exceed the period between the time of the fire and the time rehabilitation is completed. For example, if no rehabilitation is planned, consider a range fire which causes a change in vegetation which will reduce forage production for 10 to 15 years before the burned area returns to its prefire productivity level. If rehabilitation is planned within 2 years and output will be back to normal within 3 years, only 3 years of forage loss is to be entered in this item.

RECREATION EFFECT ITEMS

Item 38. **RVD's**. Enter one-half of the current annual use of recreation facilities rendered unsafe by the fire.

Item 39. **RVD's**. Enter here one-half of the current annual dispersed recreation use, other than wilderness use and hunting and fishing, for the burned area. This may be based on average annual per acre dispersed recreation use for the forest or fire management area. It is assumed that displaced dispersed recreation use will be relocated within 6 months.

Item 40. **RVD's**. Enter here one-half of the current annual wilderness use for the burned area. The 6-month assumption regarding relocation will be applied to this estimate.

WILDERNESS EFFECTS

Item 41. **RVD's**. Enter here one-half the annual change in recreation vehicle days for the indicated types of fishing and hunting resulting from the fire. This may be estimated by prorating forest level use to the area burned and fisheries influenced by the burned area. It is assumed that hunting and fishing activity will be relocated after 6 months.

WATER EFFECT ITEMS

Item 42. **AF**. Enter any increase in water yield to be anticipated from the burned area in acre feet per year.

Item 43. **Duration of Effect**. Enter the length of time an increase in water yield is expected to continue (until the area is revegetated naturally or through rehabilitation treatment), in years up to 10.

Item 44. **AF**. Enter the water yield from the burned area, which will be of reduced quality because of increased sedimentation or other causes, in acre feet per year. Note that when this effect is significant it relates to the entire water yield from the burned area and not just to the increased runoff.

Item 45. **Duration of Effect**. Enter the length of time a reduction in water quality is expected to continue (until the area is revegetated naturally or through rehabilitation treatment), in years up to 10.

OTHER EFFECTS

Item 46. **Description of Effects**. Enter here a description of any significant fire effects not included above. These may include air pollution, the lost habitats for rare or endangered species, archeological sites, research study plots, and other unique resource losses. The valuation procedures make no attempt to associate an economic value with these effects, but they may be considered on a judgmental basis in fire management decisionmaking if they are noted here.

Item 47. **Presuppression Cost**. This item is to be completed after the end of the fiscal year in which the fire occurred. Presuppression cost for a fire is total presuppression cost for the fire management area, divided by the number of statistical wildfires plus prescription fires which occurred. So, this cost is the same for every fire. Total presuppression cost includes all major appropriated protection management expenditures by the Forest, prorated to the fire management area. Do not include expenditures from Forest Fire Fuels Management. Include unreimbursed presuppression expenditures by cooperators. Divide total presuppression cost by the number of statistical wildfires plus the number of prescription fires.

Item 48. **Suppression Cost**. This item is to be completed after the end of the fiscal year in which the fire occurred. Suppression cost is developed from the average cost per acre for suppression by fire size class. Prorate major direct fire suppression related expenditures and obligations for the forest to the fire management area. Do not include cost incurred while fighting fires outside the Forest. Expenditure records provide a breakdown of expenditures by fire size class. Calculate the average cost per acre burned by fire size class. Multiply the appropriate average cost by the number of acres burned as recorded in item 8. Calculate the average suppression cost per man-day of control effort by dividing total suppression cost by total number of man-days of control effort. Multiply this average cost per man-day by the number of unreimbursed man-days of control effort recorded in item 9. Add this cost to the suppression cost based on area burned to calculate total suppression cost.

Item 49. **Life and Health Loss**. For each person listed in item 10 estimate the cost of medical treatment and of lost work time by the following process. For medical treatment cost, multiply the number of days of hospitalization by $150. This is the 1978 average cost per day of hospitalization for hospitals outside standard metropolitan statistical areas. For persons known to be hospitalized but where the length of stay is unknown, use $1,000. Use the following data to determine the value of work time lost.

Up to 20 working days: $54 per work day lost
Up to 11 calendar months: $1,160 per calendar month lost

For longer periods:

Years of employment lost *	5 percent present value of work time lost	10 percent present value of work time lost
1	$ 13,900	$ 13,900
2	25,840	24,120
3	37,850	34,750
4	49,290	44,060
5	60,180	52,680
6-10	89,840	74,150
11-15	130,570	98,730
16-20	162,480	114,000
21-25	187,650	123,480
26-35	214,060	129,360
36-45	238,520	135,930

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*For deceased persons: 65 years of age at death. These estimates are based on the average GNP per employed person less average personnel consumption per capita and represent the average net contribution to GNP of employed persons. These estimates refer to 1978 and should be updated annually. Medical treatment cost data are derived from American Hospital Association information and also need annual updating. Total the hospitalization and lost worktime costs by fire size class.

Item 50. **Property Loss**. Calculate the value of each item of property loss listed under item 14 as follows: For damaged but repairable property, use the estimate of repair cost shown in item 15. For destroyed property apply the formula:

$$\text{Value} = 1 - \frac{\text{Age}}{\text{Useful life}} \times \text{Original cost}$$

When age is greater than useful life, value is zero. The tabulation below gives useful life estimates for a range of real assets. These are based on Internal Revenue Service estimates which guide business depreciation accounting practice.

Class of property	Useful Life
	Years
Transportation equipment	
Aircraft	6
Automobiles, motorcycles, off-road vehicles, bicycles	3
Buses	9
Light trucks	4
Heavy trucks, tankers, tractors	6
Vessels, barges, and tugs	18
Land improvements	
Roads, sidewalks, canals, waterways, docks, bridges	20
Fencing	10
Production structures and equipment	
Farm buildings (except residences)	25
Agricultural machinery	10
Mining construction	10
Oil and gas wells	6
Logging equipment and machinery	6
Sawmills, portable	6
Sawmills and plywood mills, permanent	10
Pulp and paper mills	15
Other manufacturing facilities	12
Transportation and communications facilities	
Railroad structures	30
Pipelines	22
Telephone and electricity lines	19
Microwave transmission facilities	10
Other structures	
Factories, garages, machine shops, lifts, office buildings, storage buildings	45
Recreation facilities	20
Residences (includes second homes)	25
Agricultural crops and livestock	
Annual agricultural crops	1
Orchards, vineyards, and other perennial agricultural crops	10
Livestock	1

Item 51. **Rehabilitation Costs**. For each rehabilitation treatment listed under item 18, calculate total treatment cost by multiplying treatment area (item 19) by per acre treatment cost (item 20). Total rehabilitation treatment costs.

Item 52. **Timber Effects**. Calculate current net revenue changes for timber by (1) summing the sale price of cut timber products destroyed over all fires shown in item 21, (2) adding to this the sale price of stumpage under sale contract which was destroyed over all fires (items 22, 23, 24, and 25), (3) subtracting the sale price of salvage stumpage on fire sites (items 26, 27, 28, and 29), and multiplying by 1.6 to convert stumpage receipts to stumpage value to the timber processor. Calculate the present value of future changes in revenues for timber by applying the following formula:

$$PVT = D \cdot P \cdot V$$

when

PVT = the present value of future changes in timber revenues.
P = the current average price for stumpage of the sort destroyed, multiplied by 1.6.
V = the volume of unsalvaged merchantable stumpage destroyed (items 30 and 31) plus the volume of net growing stock losses (items 32 and 33).

D = 0.198. A discount factor reflecting a 5 percent discount rate and a conversion period of 100 years, and D = 0.100 for the 10 percent discount factor.

Item 53. **Forage Effects**. Calculate the value of forage destroyed by multiplying 2.4 (items 34 and 35). Calculate the present value of future changes in forage output by applying the following formula:

$$PVF = A \cdot O \ P \cdot D$$

when

PVF = the present value of future changes in revenues from forage.

A = the acres of grazing allotments burned (item 36).

O = the average annual per acre change in forage production (item 37).

P = the current price change per AUM (item 35) multiplied by 2.4.

D = a discount factor depending on the duration of effect (item 38) according to the following listing.

Duration of effect	5 percent D	10 percent D
Years		
2	1.86	1.74
3	2.72	2.48
4	3.55	3.17
5	4.33	3.79
6	5.08	4.36
7	5.79	4.87
8	6.46	5.33
9	7.11	5.75
10	7.72	6.14

Add the value of forage destroyed and the current value of future changes in forage output to compute the net forage effect and enter in item 53.

Item 54. **Recreation Effects**. Value recreational use losses shown in items 38, 39, and 40 according to the listing below, sum these losses, and enter in item 54.

Type of use	Region	Value per recreation visitor day
Developed recreation	All	$ 3.00
Dispersed recreation	1, 2, 3, 4, 10	3.00
	5, 6	3.50
	8	2.50
	9	2.00
Wilderness	1, 2, 3, 4, 10	8.00
	5, 6	10.00
	8	15.00
	9	14.00

Item 55. **Wildlife Effects**. Value the hunting and fishing use changes shown in item 41 according to the following listing, sum these changes, and enter in item 55.

Type of use	Region	Value per recreation visitor day
Anadromous sport fishing	All	$19.50
Other sport fishing	All	5.25
Small game and upland bird hunting	All	7.25
Waterfowl hunting	All	8.00
Big game hunting	All	10.50

Item 56. **Water Effects**. Value water yield increase shown in Item 42 by using the following listing:

	Duration of effect				
	1 year	2-4 years		5-10 years	
Region	5 and 10 percent	5 percent	10 percent	5 percent	10 percent
	Present value per acre-foot				
R-1	$0.75	$2.04	$1.86	$ 4.33	$ 3.65
R-2, 3, 4, 10	0.50	1.36	1.25	2.89	2.44
R-5	2.60	7.07	6.47	15.03	12.66
R-6, 8	1.50	4.08	3.74	8.67	7.30
R-9	1.00	2.72	2.49	5.78	4.87

Value a reduction in water quality shown in item 44 by using this listing:

	Duration of effect				
	1 year	2-4 years		5-10 years	
Region	5 and 10 percent	5 percent	10 percent	5 percent	10 percent
	Present value per acre-foot				
R-1, 2, 3, 4, 6, 10	$ 1.56	$ 4.24	$ 3.88	$ 9.02	$ 7.60
R-5, 8, 9	4.68	12.73	11.65	27.05	22.79

Determine the net effect by subtracting the negative effect of reduced water quality from the positive effect of increased water yield and enter in item 56.

Item 57. **Net Present Values**. Subtract the total of present values for costs and losses from the total of present values for benefits to determine net present values. Indicate negative net present values with brackets.

USING VALUATION DATA

The fire valuation procedures outlined here will provide estimates of the actual costs, losses, and benefits associated both with wildfires and prescription fires. The procedures then will provide experience data for each fire management area; data about costs, losses, and benefits which apply to that area. As valuation data are accumulated it will be possible to group fires of similar size, intensity, and location and to estimate, for example, an average loss per wildfire acre burned. This connects directly with the land management planning and fire management planning processes.

In fire management planning, changes in fire policy and program are tested to see if any would give an improved overall result. Different wildfire management programs have different costs, losses, and benefits. The most economically efficient program is the one where cost plus net loss is smallest.

The following tabulation shows the results of a recent (1977) comparison of seven different fire plans for the Deschutes National Forest. Total cost plus net loss differed widely for the seven plans. The most efficient plan had a cost plus net loss of less than half that of the least efficient plan. This points up the importance of carefully assessing fire management alternatives before reaching a final decision on which of them to implement.

Fire plan alter-native**	Area burned	Fixed, stand-by, and contract costs	Suppression cost	Resource losses	Total cost and loss
	Acres	*Dollars*			
A	1790	2,927,033	155,924	152,673	3,235,630
B	1991	1,954,477	203,662	165,259	2,323,358
C	3174	1,355,469	127,864	201,549	1,684,927
D	2371	1,318,474	77,397	184,722	1,580,593
E	2056	1,246,619	127,704	167,881	1,542,204
F	4223	1,200,000	460,000	300,000	1,960,000
G	2220	1,165,208	417,309	192,499	1,775,016

**

A. 1972 Base Plan plus all available primary and secondary forces

B. 1972 Base Plan; primary forces only.

C. 1972 Base Plan; reduced air with secondary forces.

D. 1972 Base Plan; depleted primary air with secondary forces.

E. 1972 Base Plan; primary forces reduced and relocated with limited secondary forces.

F. Alternative E; primary forces only.

G. Alternative E; reduced with limited secondary forces.

The fire valuation procedures require estimates of the change in resource output due to fire. Predictions of this sort can be made fairly readily for timber and forage outputs, but prediction capability is much less for effects on wildlife, recreational use, erosion and sedimentation, air quality changes, and other effects. It is important to develop better estimators than now exist. A study now being carried out in the Forestry Department at Colorado State University seeks to develop a computer model which will predict output effects of fire. Models of this sort and other research findings which relate fire experience with output change can improve fire valuations. For now, however, in most fire management areas, judgment will continue to play a large part in estimating the impact of fire on resource conditions and outputs. But, valuations based on judgment are more useful than no valuation at all.

The most detailed and comprehensive effort at valuation encountered during this study was carried out on the Angeles National Forest, where estimates were made of the cost per acre burned for many different fire effects. The analyst found that records of damage were satisfactory for only some of his valuation components, and that other methods--including a good deal of judgment--had to be used for many components. The Angeles National Forest office report, "Detailed Probable Fire Damage Values Study," shows that the valuation procedures recommended here may need augmentation in some fire management areas. There should be no hesitation to modify or augment these procedures to better fit local conditions.

The analysis of fire management alternatives for the Deschutes National Forest was carried out using the FOCUS model to provide estimates of the change in distribution of wildfire by size class with change in attack forces. The analysis was limited because fire valuation data were not available. Only Forest Service presuppression and suppression costs were included, although the Deschutes Protection Unit includes private, State, and BLM lands. No estimates could be made of life and health losses, of rehabilitation costs, or of property losses. Resource losses were estimates, a "damage potential," which the report states, "...should be viewed as relative between alternatives but not actual." Better and more complete valuation data are needed if analyses such as this one are to become a dependable basis for fire management planning.

It should be pointed out that the valuation procedures can be used to provide estimates of the physical change in resource output and use, as well as in their dollar value. This means that changes in fire management can be translated into changes in resource output. This is the essential information necessary to integrate fire management into the general land management planning process.

APPENDIX I

Definition of Abbreviations and Acronyms

AF = Acre feet

AUM = Animal unit month

Cds = Cords

FOCUS = Fire Operational Characteristics Using Simulation

GNP = Gross national product

OMB = Office of Management and Budget

RPA = Resources Planning Act

RVD = Recreation visitor day

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Marty, Robert J., and Richard J. Barney.
1981. Fire costs, losses, and benefits: an economic valuation procedure. USDA For. Serv. Gen. Tech. Rep. INT-108, 11 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

This paper presents a procedure to aid fire managers and fire planners on the National Forests in developing improved estimates of actual economic costs, losses, and benefits associated with fire management. Procedures are presented in guidebook form and are adaptable to other management situations.

KEYWORDS: fire, fire management, economics cost/benefits, valuation procedure

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